Teton River Subbasin Assessment And Total Maximum Daily Load


Photo courtesy of Timothy Randle, Bureau of Reclamation

Department of Environmental Quality

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South Leigh Creek

South Leigh Creek originates at an elevation of approximately 8,200 feet in the Jedediah Smith Wilderness Area. From its headwaters at South Leigh Lakes and Granite Basin Lakes, the creek flows slightly north and west to the forest boundary, dropping approximately 1,700 feet in elevation over a distance of 8 miles. From the forest boundary, the creek drops only 650 feet more in elevation over an additional 10 miles before reaching the Teton River.

According to the *Teton River Basin Study* (USDA 1992), the South Leigh Creek subwatershed is 20,551 acres in size. Slightly more than half of the subwatershed is located in Wyoming on the Caribou-Targhee National Forest, less than one-tenth of the subwatershed is located in Wyoming on privately owned land, and the remainder of the subwatershed is located in Idaho on privately owned land. In Idaho, the subwatershed is characterized by gently sloping, well-drained soils that formed in alluvium and loess, and is used primarily for irrigated cropland. Within approximately 1 mile of the Teton River, the soil becomes nearly level, is poorly drained, and is used for rangeland (USDA 1969, USDA 1992).

Flow South Leigh Creek is shown on USGS 7.5-minute topographic maps as a perennial stream from its headwaters to the Idaho-Wyoming state line. From the state line west for a distance of approximately 8 miles, streamflow is shown as intermittent. Perennial flow is restored in the final mile of the stream, apparently due to subsurface and spring flows.

Water District 1 measures flow in South Leigh Creek near the Idaho-Wyoming state line from May through October or November. Based on 18-year flow data, average flow doubles from early May to early June when it reaches an average maximum of approximately 225 cfs (Figure 43). Average flow declines slightly during middle and late June but remains at approximately 200 cfs. In early July, average flows begin to decline at a faster rate, dropping to approximately 50 cfs during the last 10 days of July. From mid-August through November, average flows remain between approximately 10 and 15 cfs.

Water is diverted from South Leigh Creek at two locations upstream of the Water District 1 gage. The largest volume of water is diverted to the Hogg Canal less than 0.5 miles upstream of the state line. In a relatively high flow year such as 1996, when 380 cfs was measured on June 15 at the gage on South Leigh Creek, 55 cfs was measured in the Hogg Canal.

In a relatively low-flow year such as 1987, when 70 cfs was measured on June 13 at the gage on South Leigh Creek, 35 cfs was measured in the Hogg Canal. The Kilpack Canal also diverts water upstream of the Water District 1 gage, but the amount usually ranges from only 1 to 5 cfs. In Idaho, Water District 1 measures flow in the Desert, Gale-Moffat, Bell-

McCracken, Breck, Sorenson, and Cook diversions. The amount of water removed from South Leigh Creek by these diversions at any time is highly variable, and may range up to 25 cfs.

§303(d)-Listed Segment The segment of South Leigh Creek shown on the 1998 §303(d) list includes all of the creek in Idaho, extending from the Idaho-Wyoming state line to the Teton River (Figure 44). The pollutant of concern is sediment. Beneficial Use Reconnaissance Program sampling was conducted at two sites on South Leigh Creek in 1995. Based solely on MBI scores, the support status of cold water aquatic life at the upstream site located near the Idaho-Wyoming state line was assessed as “needs verification” and the support status at the lower site, located 7 miles downstream of the state line, was assessed as “not full support” (Figure 45). The HI score at the upper site was relatively high (96) and indicated that habitat was probably not responsible for limiting development of the macroinvertebrate community. In contrast, the HI score at the lower site (78) was far below the value considered to support macroinvertebrates in the ecoregion (89). Substrate embeddedness at each of these sites was ranked as sub-optimal, but the percentage of surface fines less than 6 mm in diameter was 20% or less at each location.

In 1998, a site located less than 1 mile downstream of the Idaho-Wyoming state line was sampled and produced among the highest MBI (4.98) and HI (100) scores recorded for the Teton Subbasin. If these scores had been assessed according to guidelines used to prepare the 1998 §303(d) list, the status of cold water aquatic life would have been assessed as “full support.” Substrate embeddedness at this site was ranked optimal and the percentage of subsurface fines less than 6 mm in diameter was only 6%.

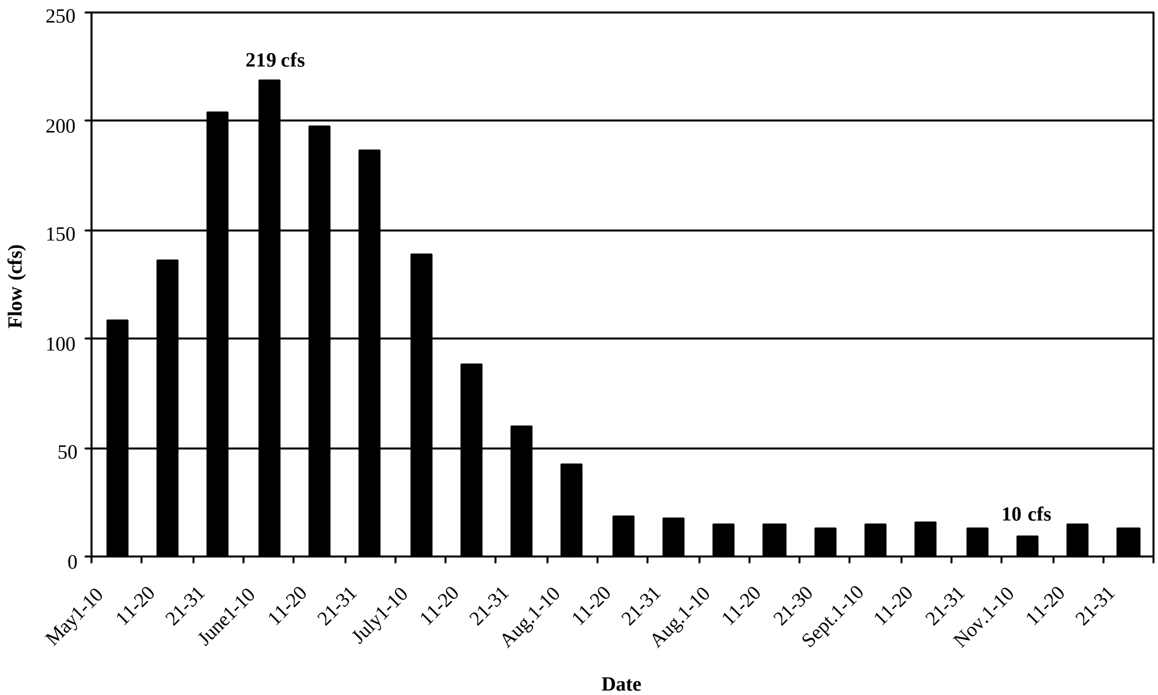

Figure 43. Eighteen-year discharge measurments for South Leigh Creek.

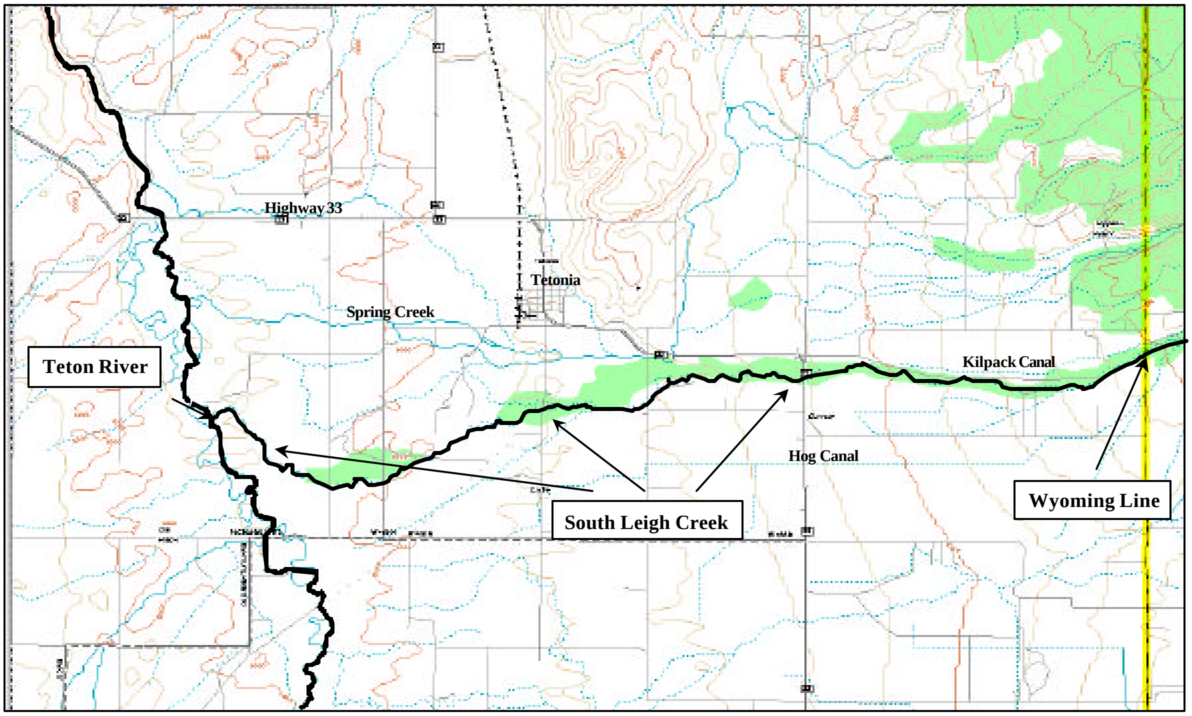

Figure 44. Boundaries of the segment of South Leigh Creek identified on Idaho's 1996 section 303(d) list of water quality-impaired water bodies. Pollutant of concern included sediment.

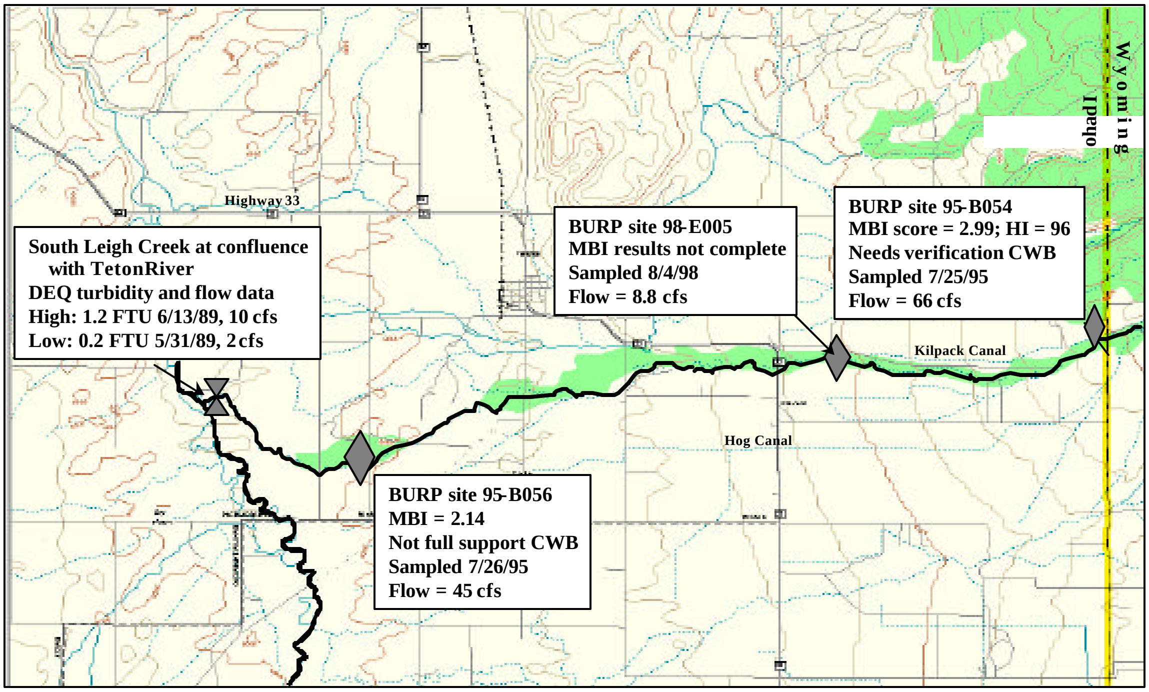

Figure 45. Data collection sites on South Leigh Creek

Resource Problems Identified by the USDA and TSCD The *Teton River Basin Study* (USDA 1992) estimated that the total sediment yield from agricultural lands in the South Leigh Creek subwatershed was 15,228 tons/year. Of that amount, 81% originated from land use and 19% originated from streambanks. Implementing structural practices, identified as Alternative 2 in the *Teton River Basin Study* (USDA 1992), was expected to reduce total sediment yield to 10,359 tons/year by reducing land use erosion by 31% and streambank erosion by 35%. The majority of the agricultural land located in the subwatershed occurs within treatment units 9 or 12, with small portions occurring in treatment units 6, 7, and 10/11. The causes of resource problems in treatment unit 9 were identified as sheet, rill, gully, wind, and irrigation-induced erosion caused by pulverized soil surface conditions following potato harvest, spring barley seedbeds that lack adequate surface residues, fall disking, over-tilled mechanical summer fallow, up and downhill potato planting, soil compaction, and over application of irrigation water. The causes of resource problems identified for treatment unit 12 were overgrazing of uplands, season of use by livestock, roads, overland runoff/surface and gully erosion, and urbanization/home building (USDA 1992).

Water Quality Data The results of water quality sampling conducted by DEQ in 2000 did not indicate high concentrations of suspended sediment in South Leigh Creek at the locations and times sampled (Appendix I). The locations sampled corresponded to BURP sites 95-B054 and 95-B056 (Figure 45). The maximum concentration of TSS measured at the upstream site on June 14 (16.4 mg/L) was far below the designated target of 80 mg/L. The maximum turbidity value (1.2 NTU), which was also measured at the upstream site on June 14, was also far below the criterion specified in Idaho’s water quality standards (i.e., not greater than 50 NTU above background).

The decrease in concentration of TSS from the upstream site (16.4 mg/L) to the downstream site (0.8 mg/L) on June 14 indicated that sediment may have been deposited in the stream bed between these locations. The decrease in flow from 94 cfs at the upstream site to 22 cfs at the downstream site would have facilitated sediment loss from the water column.

The data collected in 2000 confirm that water does not always flow from the state line to the lower sampling site. At the state line, flow decreased from 94 cfs on June 14 to 8 cfs on August 22. At the downstream site, flow decreased from 22 cfs on June 14, to 3 cfs on June 27, and finally 0 cfs on July 26 and August 22. In 1995, BURP sampling was conducted at the upper site on July 25 and at the lower site on July 26. Flows at these locations were 66 cfs and 45 cfs, respectively. In contrast, on July 26, 2000, the flow at the upper site was only 11 cfs and, at the lower site, 0 cfs.

Subsurface sediment analyses performed at both sampling sites in 2000 clearly indicated that sediment deposition was greater at the downstream site than at the upstream site. At the site located near the state line, the cumulative percentage of particles smaller than 0.85 mm was 9%, whereas the cumulative percentage at the downstream site was 21%. Similarly, the cumulative percentage of particles smaller than 6.3 mm at the upstream site was 27% and the cumulative percentage at the downstream site was 42%. Sediment particle sizes at the upstream site are within the targets shown in Table 23, but sediment particle sizes at the downstream site exceed the target for particles less than 0.85 mm by 11% and the target for particles less than 6.3 mm by 15%.

Samples of water from South Leigh Creek at its confluence with the Teton River were collected by DEQ on four dates in 1989 (Drewes 1993). Flows ranged from 2 to 10 cfs and turbidity values were less than 1.2 FTU (i.e., less than approximately 1.2 NTU). Total suspended solids concentrations were not measured but low turbidity values indicate that large concentrations of suspended sediment were not being transported to the river. Phosphorus and orthophosphate concentrations were below detection levels and NO_2 + NO_3 concentrations were less than 0.09 mg/L, indicating that excessive concentrations of nutrients were also not being transported to the river from South Leigh Creek.

Fisheries South Leigh Creek was electrofished by DEQ at the BURP site located near the state line (95-B054) in 1996 and at the BURP site located 0.5 miles upstream of the Highway 33 bridge (98-E005) in 1998. Thirty-one cutthroat trout ranging in size from 30 to 319 mm and two sculpin were collected at the upstream site near the state line; no fish were collected at the downstream site near the Highway 33 bridge. Based on the number of year classes collected at the upstream site, South Leigh Creek was assessed as supporting salmonid spawning.

The Caribou-Targhee National Forest electrofished South Leigh Creek in August 1998 from the forest boundary upstream almost to the boundary of the Jedediah Smith Wilderness Area. Nineteen subsamples produced 242 cutthroat trout ranging in size from less than 50 mm to more than 300 mm, and neither brook trout nor rainbow trout were collected.

Discussion The hydrologic regime of South Leigh Creek is similar to that of Darby Creek, though the point at which the South Leigh Creek channel becomes dry is less well defined. The main source of water in upper South Leigh Creek is snowmelt runoff; the source of water in lower South Leigh Creek is upwelling subsurface water and a spring or springs located approximately 1 mile upstream of South Leigh Creek's confluence with the Teton River. In late May, June, and early July, runoff is usually sufficient to provide flow from the headwaters of South Leigh Creek to the Teton River. Otherwise, the channel is dry from at least 8 to 9 miles west of the state line. In 1996, the Henry's Fork Watershed Council Water Quality Subcommittee recommended that South Leigh Creek be divided into two segments at the location of the spring that restores flow to the lower channel (i.e., SE1/4 NE1/4 S1 T5N R44E). From the spring upstream to the Idaho-Wyoming state line, the flow in South Leigh Creek is intermittent and heavily diverted during the irrigation season. Downstream of the spring, flow in South Leigh Creek appears to be relatively constant.

Conclusions Conclusions regarding the water quality status of South Leigh Creek are listed below.

1. The capacity of South Leigh Creek to support the beneficial uses of cold water aquatic life and salmonid spawning in the segment below the state line probably varies on a yearly basis depending on flow conditions. Flow in the segment downstream of the spring appears to be sufficient to support aquatic life uses at all times, and BURP sampling should be conducted on this segment to assess beneficial use support status. Habitat index scores, one MBI score, and fisheries data for the segment of South Leigh Creek between the state line and Highway 33 indicate that cold water aquatic life and salmonid spawning were fully supported. The reason for the indeterminant MBI score obtained in 1995 is

unknown but may have been related to high flow conditions. The limited amount of water column sampling conducted on South Leigh Creek has not detected the transport of excessive concentrations of suspended sediment. This is consistent with the observations of local residents who report that the water in South Leigh Creek is always very clear and the substrate visible. However, subsurface sampling indicated that deposition of fine sediment has occurred approximately 8 miles downstream of the state line where the stream bed was confirmed dry in July 2000. Developing a TMDL for sediment is appropriate, though stream segments must be better defined by DEQ for the purpose of assessing beneficial uses.

2. To protect beneficial uses, the water quality targets for sediment shown in Table 15 should not be exceeded at any location in South Leigh Creek.

3. The results of recent fish sampling indicate that South Leigh Creek supports a self-sustaining population of cutthroat trout. Because there are no known fish barriers between privately owned land and federal land, fish probably migrate extensively between these areas, limited only by the extent of downstream flow. The absence of brook trout and rainbow trout in all of the samples collected also indicates that the intermittent nature of South Leigh Creek downstream of the state line may limit upstream migration of fish from the Teton River to the upper segment of South Leigh Creek.

North Leigh Creek and Spring Creek

North Leigh Creek and Spring Creek are discussed together because both are located in the Spring Creek subwatershed, as delineated in the *Teton River Basin Study* (USDA 1992). The subwatershed is divided from east to west by the Idaho-Wyoming state line, and approximately half of its 27,962 acres are located on the Caribou-Targhee National Forest in Wyoming. With the exception of small parcels of privately owned land in Wyoming and land near the state line that is managed by BLM, the remaining acreage is located in Idaho and is privately owned.

North Leigh Creek is a tributary of Spring Creek and originates at an elevation of approximately 8,200 feet on the Jedediah Smith Wilderness. From its headwaters above Green Lake, it flows slightly north and west to the forest boundary, dropping approximately 1,700 feet in elevation over a distance of ten miles. From the forest boundary, it flows 0.5 miles to the Idaho-Wyoming state line, and another 3.5 miles to its confluence with Spring Creek (Figure 46).

The USGS 7.5-minute topographic map shows Spring Creek originating at a small, spring-fed pond located less than 3 miles west of the state line and approximately 1.5 miles north of the point at which North Leigh Creek enters it. From the pond, the channel flows northwest approximately 0.5 miles where it converges with an intermittent channel flowing from the north. From this point, Spring Creek flows almost directly south, passes beneath Highway 33, then flows west toward the Teton River over a total distance of approximately 7.5 miles (Figure 46).

In Idaho, the Spring Creek subwatershed is characterized by gently sloping, well-drained soils that formed in alluvium and loess, and is used in almost equal parts as rangeland, irrigated and non-irrigated cropland, and irrigated pastureland. Within approximately 2 miles of the Teton River, the soil becomes nearly level, is poorly drained, and is used for pastureland and rangeland (USDA 1969, USDA 1992).

Flow North Leigh Creek is shown as a perennial stream on USGS 7.5-minute topographic maps from its headwaters to approximately 0.5 miles west of the state line. At this point it branches into Middle Leigh and North Leigh Creeks, and both channels are shown as intermittent as they flow directly west almost 4 miles to Spring Creek (Figure 46).

Water District 1 measures flow in North Leigh Creek approximately 0.2 mile above the state line from April or May through October or November. Based on 18-year data, average flow almost triples from the first week of May to the first week of June, when it reaches a maximum of approximately 210 cfs (Figure 47). By mid-August, average flow returns to approximately 10 cfs. North Leigh Canal, the first of five diversions monitored by Water District 1, is located downstream of the North Leigh Creek gage just east of the state line. Four diversions occur within the next 3 stream miles in Idaho: Weaver Ditch, Si Canal (also referred to as the SI Canal or the Edison and Ricks Canal), Center Canal, and Hubbard Ditch. Most water is diverted to the North Leigh Canal, followed by the Center Canal and Hubbard Ditch. The amount of water diverted at each location is quite variable, but generally does not exceed 20 cfs.

The intermittent nature of lower North Leigh Creek was confirmed by sampling conducted by DEQ in 2000 at the bridge immediately upstream from the confluence of North Leigh Creek with Spring Creek. Discharge decreased from 50 cfs on June 14, to 20 cfs on June 27, to 0 cfs on July 26. The channel was also dry when it was visited on August 22. Spring Creek is shown on the USGS 7.5-minute topographic map as perennial from its origin to the Teton River.

Flow has slowed somewhat due to an increased number of beaver dams and ponds in the reach of Spring Creek upstream of North Leigh Creek and downstream almost to Highway 33 (Breckenridge personal communication, Thomas personal communication). They also have observed that the Spring Creek channel occasionally becomes dry from approximately 1 mile west of Tetonia to 2.5 miles west of Tetonia. DEQ sampled Spring Creek at a location approximately 1.5 miles west of Tetonia in 2000. On August 22, the last day sampled, the channel still contained water and discharge was 1.75 cfs.

Water District 1 measures flow in Spring Creek below Highway 33 and at nine downstream diversions. The chart of 18-year flow data for Spring Creek is similar in shape to the chart for North Leigh Creek, but the average flows are generally 30 cfs lower in Spring Creek than in North Leigh until the first week of July when the averages become nearly equal (Figures 47 and 48).

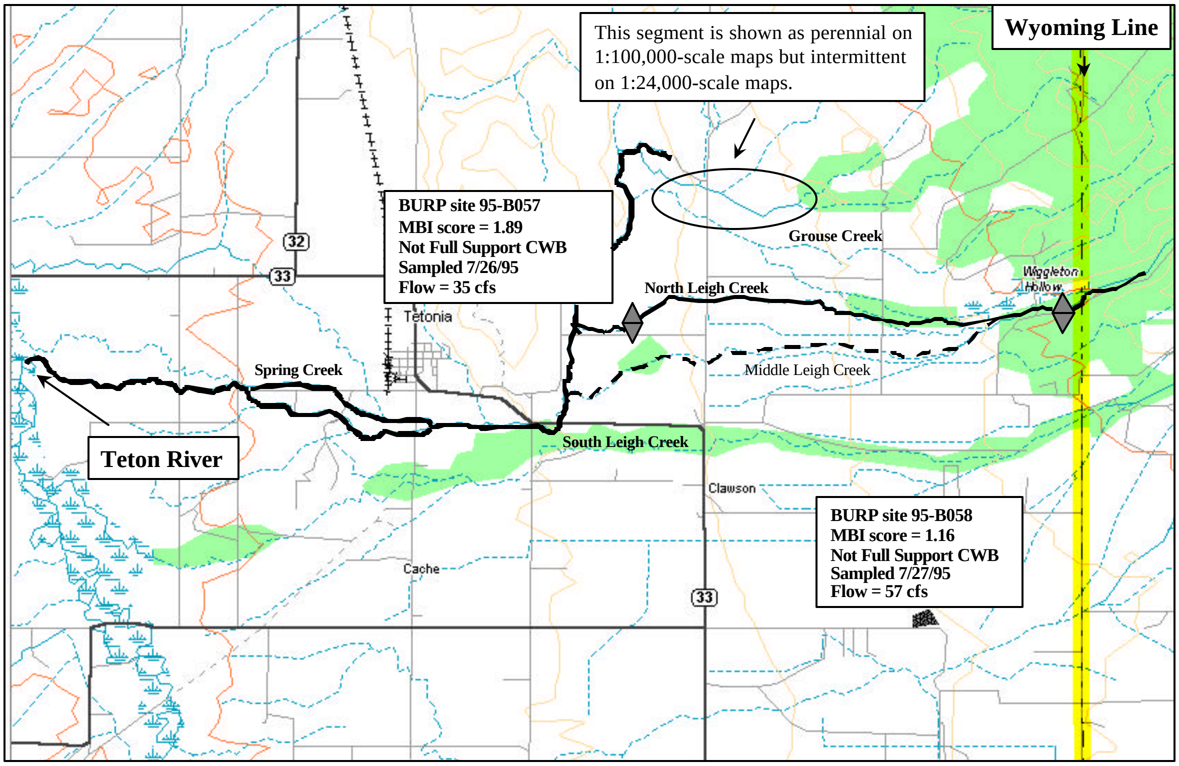

Figure 46. Boundaries of the segment of Spring Creek identified on Idaho's 1998 section 303(d) list of water quality-impaired water bodies, and locations of BURP sites on North Leigh Creek.

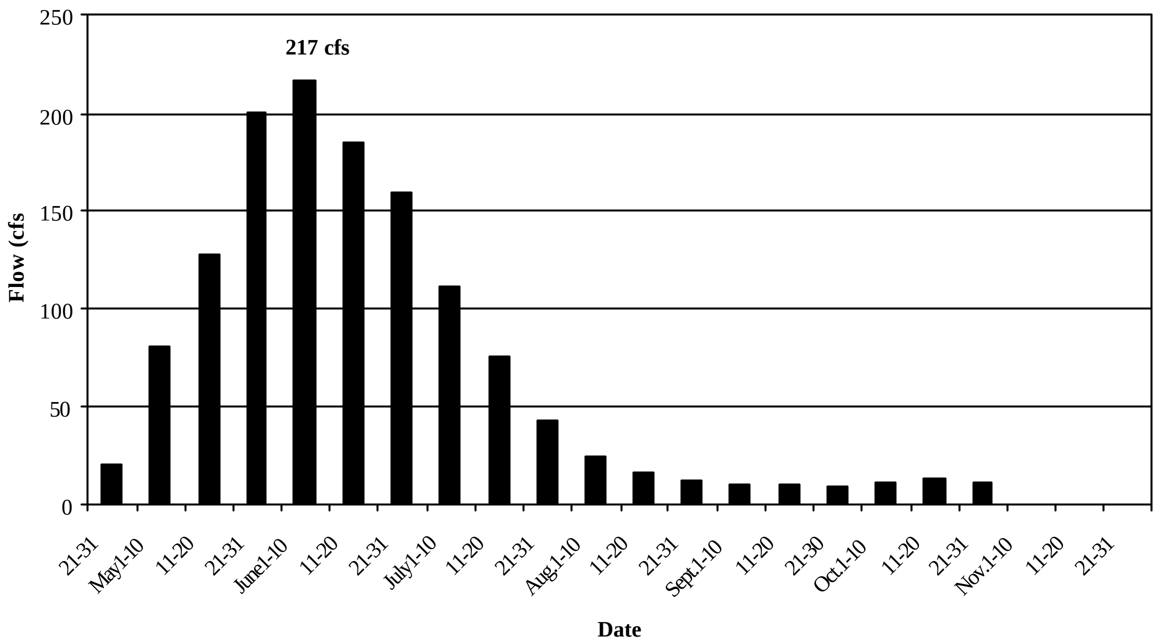

Figure 47. Eighteen-year average flows measured on North Leigh Creek.

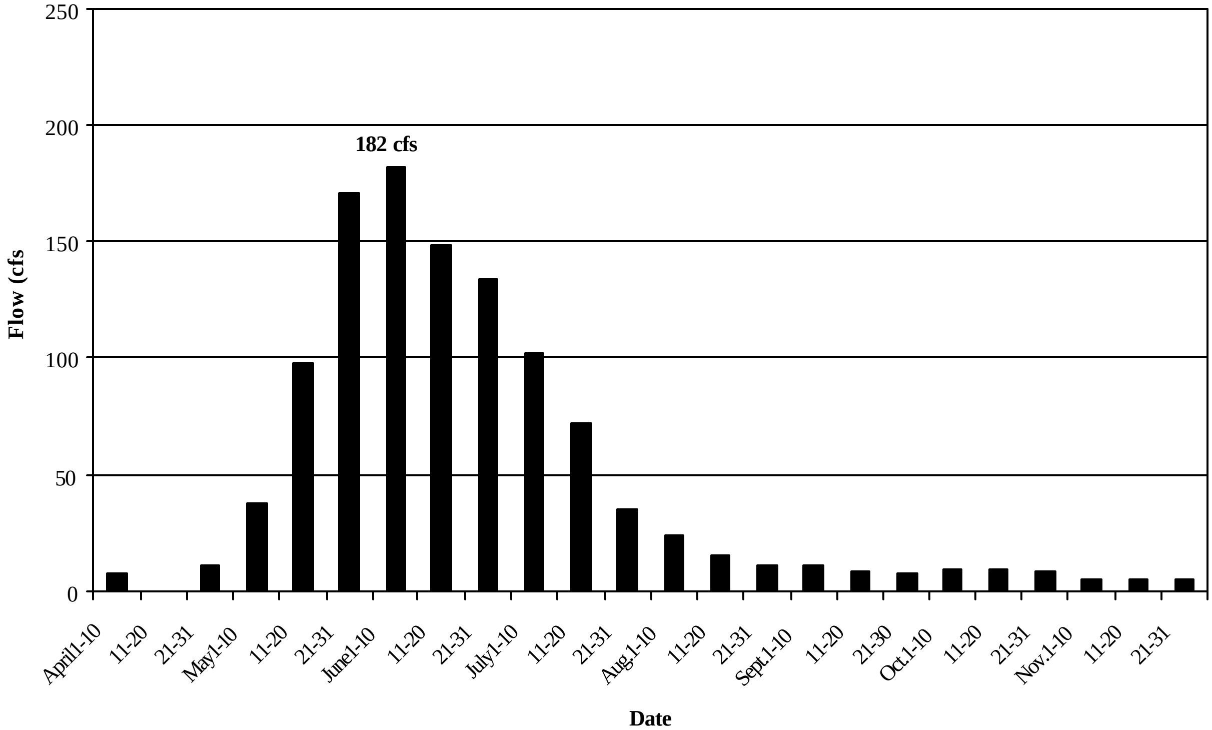

Figure 48. Eighteen-year discharge measurements for Spring Creek.

§303(d)-Listed Segment The segment of North Leigh Creek shown on the 1998 § 303(d) list extends from the Idaho-Wyoming state line to Spring Creek (Figure 46), and the pollutant of concern is unknown because the stream was added to the 1998 list based on an assessment of BURP data collected in 1995. The segment of Spring Creek shown on the 1998 §303(d) list extends from the Idaho-Wyoming state line to the Teton River. The upper boundary is incorrect because, as explained above, Spring Creek originates almost 3.5 miles west of the state line (Figure 49). This error occurred because the segment was defined using a 1:100,000-scale map which incorrectly shows Spring Creek originating in headwater streams located east and west of the Idaho-Wyoming state line. The pollutants of concern for Spring Creek are sediment, flow alteration, and temperature.

The MBI scores obtained by DEQ in 1995 indicated that the beneficial use of cold water aquatic life was not supported at the BURP sites sampled in North Leigh Creek or Spring Creek (Figures 46 and 49). The site sampled on North Leigh Creek just below the state line produced the lowest MBI score in the Teton Subbasin (1.16) despite a relatively high HI score (103). The lower site on North Leigh Creek, just above its confluence with Spring Creek, also produced a low MBI score (1.89) but relatively high HI score (102). The MBI score for the upstream site on Spring Creek (1.26) was also well below the limit for support of cold water aquatic life (3.5) and the HI score (86) was slightly below the value considered adequate to support cold water aquatic life (89). The BURP results for Spring Creek were much improved at the downstream site, with an MBI score (2.99) within the "needs verification" and an HI score (94) adequate to support cold water aquatic life. A second upstream site was sampled on Spring Creek in 1997, but the MBI remained low (1.31) and the HI score (50) was the lowest measured in the Teton Subbasin. The low MBI scores for all sites were caused primarily by high numbers of sediment-tolerant flies (*Simulium sp.* and Chironomidae). This result was unexpected for the North Leigh Creek site near the state line (95-B058) because of stream channel type, good HI score, and flow conditions. Substrate embeddedness at this site was rated optimal, the percentage of fine sediment less than 6 mm was only 24%, and the percentage of fine sediment less than 1 mm was 14%. Conditions at the downstream site (95-B057) were only slightly more conducive to sediment-tolerant macroinvertebrates. Embeddedness was rated sub-optimal, percentage of fine sediment less than 6 mm increased to 28%, and percentage of fine sediment less than 1 mm in diameter increased to 23%.

The substrate characteristics of upper Spring Creek are much more likely to produce an abundance of sediment-tolerant macroinvertebrates. Spring Creek originates in a low-gradient meadow in silty clay loam soil. Flow is relatively constant because the stream is spring-fed, which contributes to the development of low-gradient, depositional stream channels. At BURP site 95-B024, which was located below the outlet of the pond that supplies most of the flow in Spring Creek, 75% of the substrate was less than 6 mm in diameter and 64% was less than 1 mm in diameter. At BURP site 97-M152, which was in a channel that received one-tenth the flow of the other channel (0.4 cfs), 100% of the substrate was less than 1 mm in diameter. Moving downstream, the amount of substrate sediment decreases, possibly due to increased flow, greater flow fluctuations, changes in soil type, and entrapment of fine sediment in beaver ponds. At the downstream BURP site on Spring Creek (95-B055), the percentage of surface fine sediment was only 22%. However, even under these conditions, the MBI score did not indicate support of cold water aquatic life.

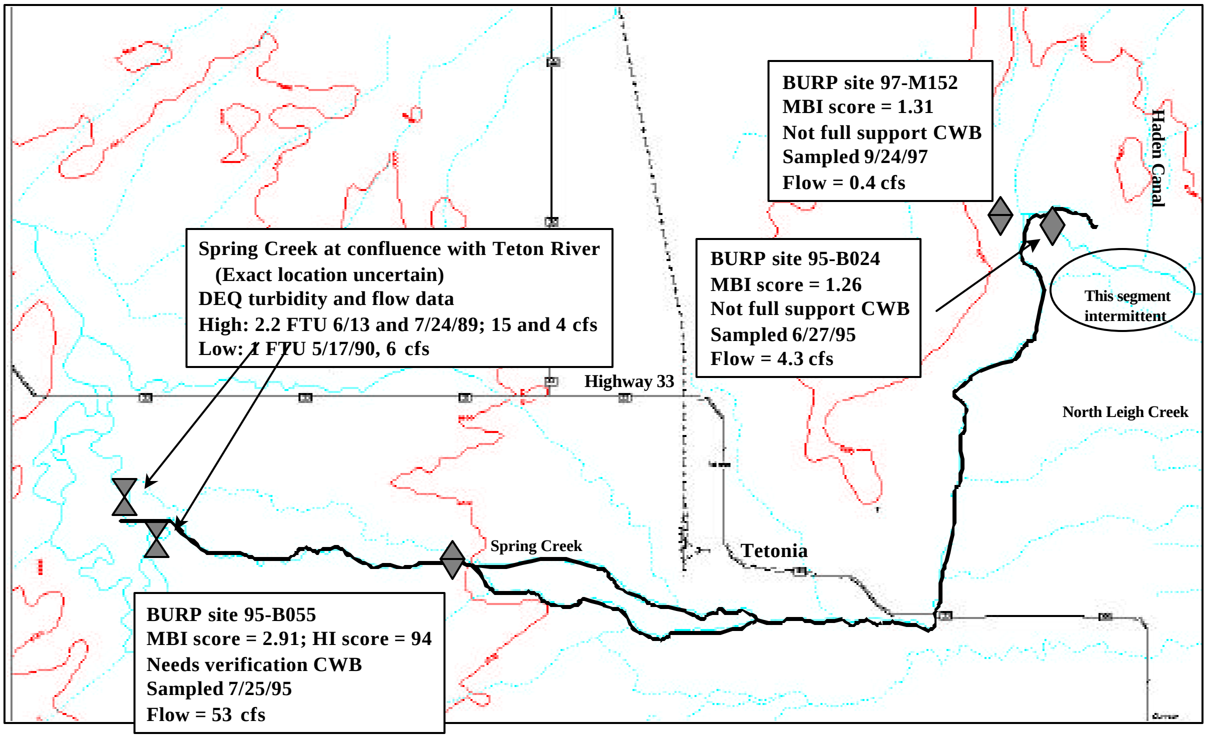

Figure 49. Data collection sites on Spring Creek.

Resource Problems Identified by the USDA and TSCD The *Teton River Basin Study* (USDA 1992) estimated that the total sediment yield from agricultural lands in the Spring Creek subwatershed was 20,844 tons/year. Of that amount, 82% originated from land use and 18% originated from streambanks. Implementing structural practices, identified as Alternative 2 in the *Teton River Basin Study* (USDA 1992), was expected to reduce total sediment yield to 14,211 tons/year by reducing land use erosion by 31% and streambank erosion by 35%. The majority of the agricultural land located in the subwatershed occurs within treatment units 9, 12, 4, or 10/11 with small portions occurring in treatment units 1,5,6, and 7. The causes of resource problems in unit 9 were identified as sheet, rill, gully, wind, and irrigation-induced erosion caused by pulverized soil surface conditions following potato harvest, spring barley seedbeds that lack adequate surface residues, fall disking, over-tilled mechanical summer fallow, up and downhill potato planting, soil compaction, and over application of irrigation water. The causes of resource problems identified for treatment unit 12 were overgrazing of uplands, season of use by livestock, roads, overland runoff/surface and gully erosion, and urbanization/home building. The cause of resource problems in treatment unit 4 was identified as transport of sediment and nutrients to surface waters during high-runoff events; the causes of resource problems identified for treatment unit 10/11 were overgrazing in the riparian area; removing stream-side shrubs, trees, and other vegetation; straightening sections of stream channel; improperly placing culverts; flooding; stream evolution; reduced sub-water flows; poorly controlled flood irrigation systems; and upland erosion (USDA 1992).

Water Quality Data The results of water quality sampling conducted by DEQ in 2000 did not indicate high concentrations of suspended sediment in North Leigh Creek near its confluence with Spring Creek, or in Spring Creek at BURP site 95-B055 (Appendix I). The maximum concentrations of TSS measured in North Leigh Creek (4.5 mg/L) and Spring Creek (12.1 mg/L) on June 14 were far below the designated target of 80 mg/L. The maximum turbidity values, 2.2 NTU for North Leigh Creek and 5.4 NTU for Spring Creek, were also far below the criterion specified in Idaho's water quality standards (i.e., not greater than 50 NTU above background).

Flow data collected in 2000 confirmed the intermittent status of North Leigh Creek but not Spring Creek. Discharge decreased from 50 cfs on June 14, to 20 cfs on June 27, to 0 cfs on July 26 and August 22 in North Leigh Creek at its confluence with Spring Creek. The discharge in Spring Creek at the downstream sampling site was less than 2 cfs the last day of sampling.

An analysis of subsurface sediment at the lower Spring Creek sampling site, as measured in 2000, indicated that sediment deposition has occurred. The cumulative percentage of particles smaller than 0.85 mm was almost 20% and the cumulative percentage of particles smaller than 6.3 mm was 42%. These values exceeded the targets shown in Table 15 by 10% for particles less than 0.85 mm and by 15% for particles less than 6.3 mm.

Because temperature is a pollutant of concern for Spring Creek, a temperature data logger was placed in the vicinity of BURP site 95-B055 from June to August 2000. Temperatures exceeded the maximum daily criterion for cold water aquatic life almost daily from mid-July through mid-August, and the average daily criterion on three day (Figure 50). The stream is wide and shallow in the area where the data logger was placed, and is almost devoid of riparian vegetation. These factors almost certainly contribute to high water temperatures. However, because the stream

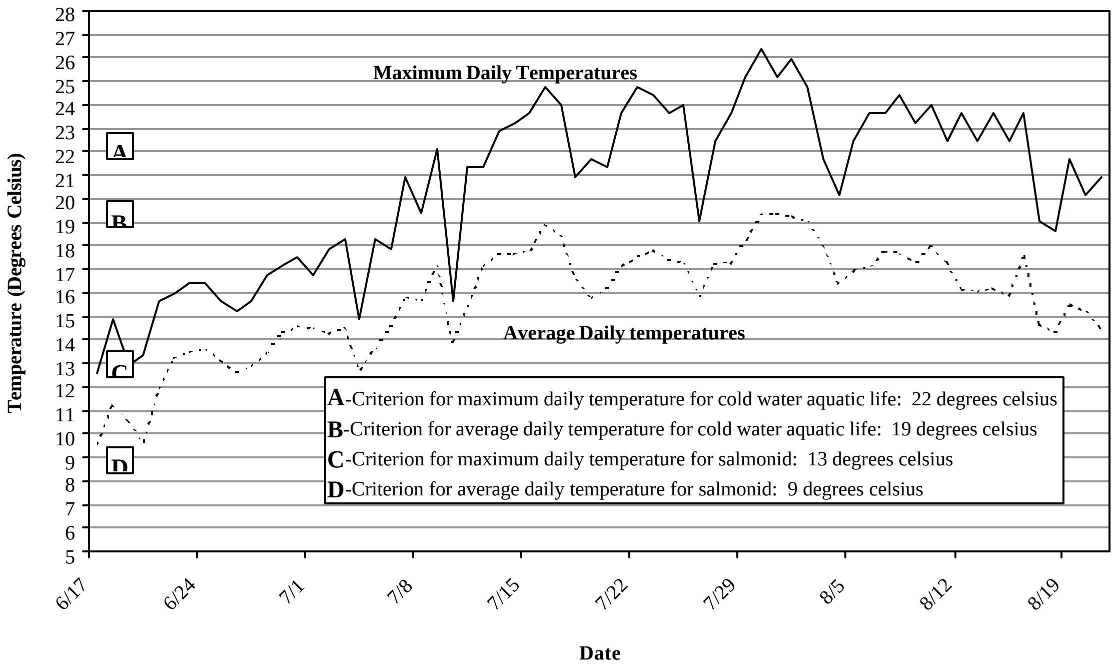

Figure 50. Water temperatures collected in Spring Creek from June 17 through August 21, 2000.

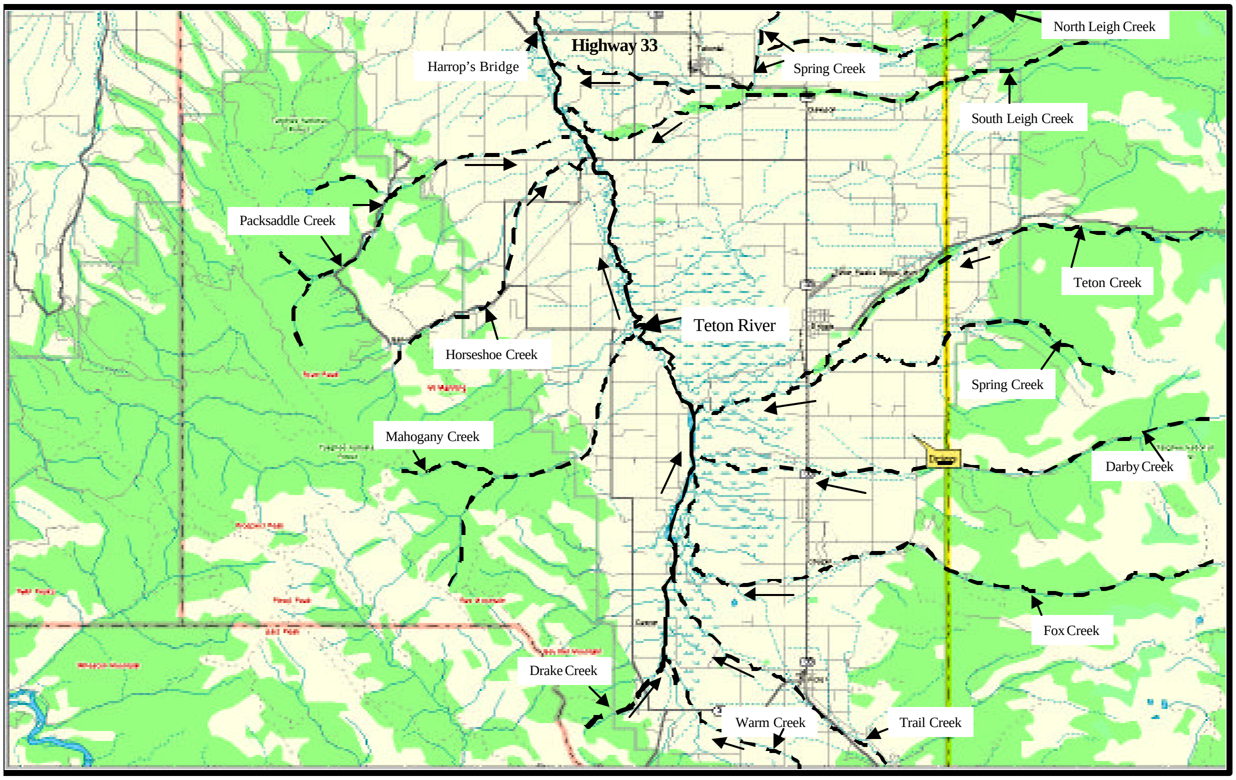

Figure 51. Teton River from the headwaters to Highway 33 (Harrop's Bridge).

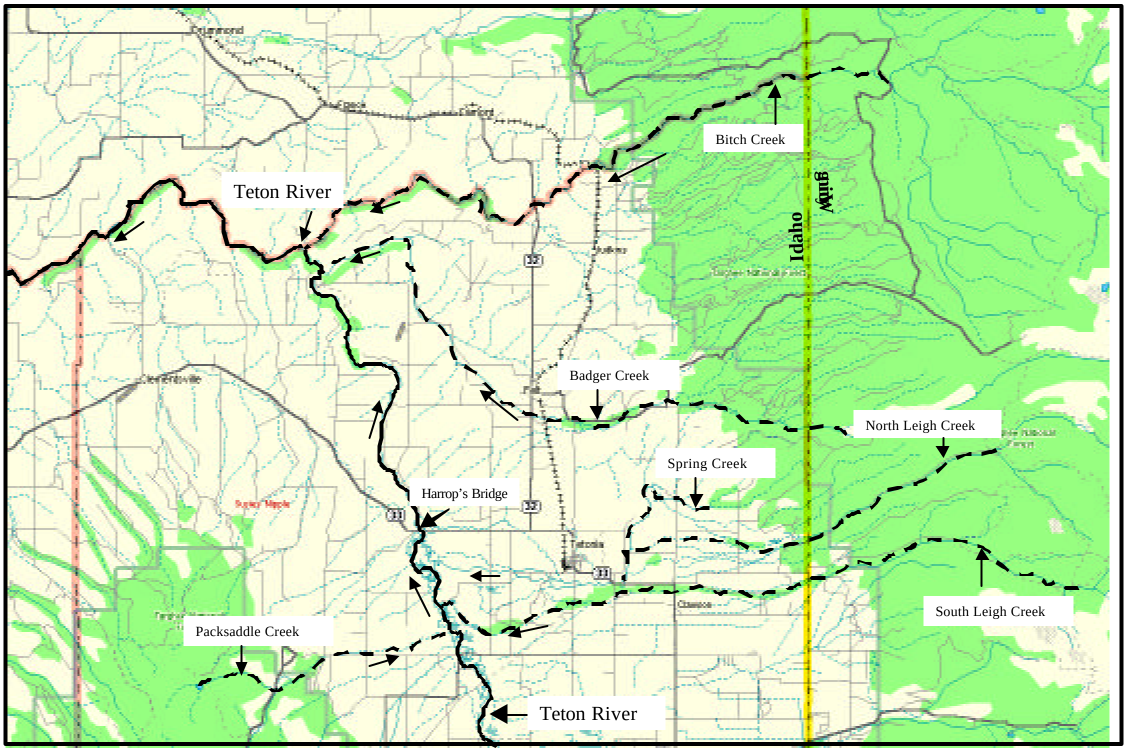

Figure 52. Teton River from Highway 33 (Harrop's bridge) to Bitch Creek.

originates at a spring, it is possible that the temperature of the water is naturally higher than temperatures in streams that receive snowmelt. Additional temperature monitoring throughout the stream reach of Spring Creek should be conducted to determine the factors contributing to temperature criteria exceedances.

Samples of water from Spring Creek at its confluence with the Teton River were collected by DEQ on seven dates from 1988 to 1990 (Drewes 1993). Flows ranged from 2 to 15 cfs and turbidity values were less than 2.2 FTU (i.e., less than approximately 2.2 NTU). Total suspended solids concentrations were not measured but low turbidity values indicate that large concentrations of suspended sediment were not being transported to the river. Phosphorus and orthophosphate concentrations were at or below 0.05 mg/L and NO_2 + NO_3 concentrations were less than 0.16 mg/L, indicating that excessive concentrations of nutrients were also not being transported to the river from Spring Creek. However, the fecal coliform bacteria analysis on July 24 exceeded the primary contact recreation criterion of 500 colonies/mL by 1,700 colonies/mL.

Fisheries North Leigh Creek was electrofished by DEQ at BURP site 95-B058 in 1996; Spring Creek was electrofished by DEQ at BURP site 95-B024 in 1996 and at BURP site 97-M152 in 1997. Four year classes of brook trout, including juveniles, and one sculpin were collected in North Leigh Creek near the state line. Three year classes of brook trout, including juveniles, and 16 longnose dace were collected in Spring Creek approximately 200 yards downstream of the headwater pond. These data were sufficient to assess both streams as fully supporting the beneficial use of salmonid spawning (DEQ 1998). Spring Creek was also electrofished in the intermittent channel that converges with the pond outlet, but no fish were collected.

Discussion Sediment in North Leigh Creek appears to be originating in Wyoming, as indicated by data at the Idaho-Wyoming state line. The boundaries of North Leigh Creek must be reconfigured on the basis of perennial flow for the purpose of assessing beneficial uses.

The beneficial uses of Spring Creek upstream of North Leigh Creek should be assessed separately from the segment downstream. The BURP protocol may not be appropriate for assessing the upper segment of Spring Creek.

Temperatures regularly exceeded water quality criteria in lower Spring Creek in June, July, and August 2000 (Figure 50). The stream in this area is very wide and shallow with little shade. However, the temperature of Spring Creek water may naturally be higher than other streams in the Teton Valley because it flows relatively far from its spring source. Additional temperature monitoring in the upstream segments of Spring Creek should be conducted. The downstream extent of Spring Creek from the point at which temperature was monitored is unknown and should be better characterized

Conclusions Conclusions regarding the water quality status of North Leigh Creek and Spring Creek are listed below.

1. It is appropriate to develop a TMDL for sediment for Spring Creek (which includes North Leigh Creek as a tributary), though stream segments must be better defined by DEQ for the purpose of assessing beneficial uses.

2. To support beneficial uses, the water quality targets for sediment shown in Table 15 should not be exceeded at any location in Spring Creek or North Leigh Creek.

3. A temperature TMDL for Spring Creek is warranted, but has been rescheduled for the end of 2002.

4. While Spring Creek is impaired due to flow alteration, a TMDL for flow will not be developed. The EPA does not believe that flow (or lack of flow) is a pollutant as defined by section 502(6) of the CWA. DEQ is not required to establish TMDLs for waterbodies impaired by pollution but not pollutants, so it is the policy of the state of Idaho to not develop TMDLs for flow alteration.

Teton River

The listed segments of the Teton River (Headwaters to Trail Creek, Trail Creek to Highway 33, and Highway 33 to Bitch Creek) together comprise the Teton Valley segment of the river. According to the Water Quality Subcommittee of the Henry's Fork Watershed Council, the Teton River begins at the confluence of Drake and Warm Creeks. Both of these small streams originate at springs or in small drainages on the north slope of the Big Hole Mountains, and converge on privately owned land at the south end of Teton Valley (Figure 51).

Approximately 2 miles downstream, Trail Creek enters the river from the southeast. Trail Creek originates on the Caribou-Targhee National Forest in the Teton Mountains and delivers substantial flows to the river during spring runoff. During the irrigation season, Trail Creek is diverted to the Trail Creek canal and pipeline. The pipeline was installed about 30 years ago and provides water to a sprinkler irrigation system that serves approximately 7,000 acres in the upper Teton Valley near Victor.

Major tributaries of the Teton River originating in the Teton Mountains are Trail Creek (including Moose and Game Creeks), Fox Creek, Darby Creek, Teton Creek, South Leigh Creek, Badger Creek, and Bitch Creek (Figures 51 and 52). Spring Creek originates at a spring below the Teton Mountains but receives mountain runoff from North Leigh Creek. Major tributaries of the Teton River originating in the Big Hole Mountains include Mahogany Creek, Twin Creek, Horseshoe Creek, and Packsaddle Creek (Figures 51 and 52).

In the upper Teton Valley, the Teton River is a low-gradient stream that flows through silty clay loam. In the lower Teton Valley, the river has downcut through volcanic deposits to form a steep-walled, basalt-lined canyon. Land use in the upper Teton Valley consists primarily of rangeland on the extensive wet meadows east of the Teton River, and irrigated and nonirrigated cropland on elevated slopes east of the wetlands and west of the river. In the lower valley, the river channel is confined below rolling irrigated and nonirrigated cropland.

Flow Discharge has been measured on the upper Teton River since 1961 at USGS gage station 13052200, *Teton River above South Leigh Creek near Driggs, ID*. This gage is located on the southeast side of Cache Bridge in the east channel of the river. The drainage area at this point is approximately 335 square miles and includes major tributaries upstream of Horseshoe Creek. As of water year 1999, recorded discharges ranged from 54 cfs on November 23,1977, to 2,980 cfs on June 11, 1997 (Brennan *et al.*1999). Discharges typically range from lows between 100 and 200 cfs in December, January, and February to highs between 1,000 and 2,000 cfs in May and June. Maximum discharges less than 600 cfs were recorded in 1966 and 1992 (Figure 53).

Flow data on Teton River tributaries and diversions from tributaries are measured during the irrigation season by Water District 1. The highest average discharges are for Teton Creek and Trail Creek at more than 400 cfs; intermediate discharges occur in Darby, South Leigh, North Leigh, and Badger Creeks at approximately 200 cfs; and low discharges occur in Horseshoe and Packsaddle Creeks at less than 50 cfs.

§303(d)-Listed Segments Three segments of the Teton River appeared on the 1998 §303(d) list: headwaters to Trail Creek, Trail Creek to Highway 33, and Highway 33 to Bitch Creek. Habitat alteration was listed as a pollutant of concern for all three segments, sediment was listed as a pollutant of concern for the segments from Trail Creek Highway 33 and from Highway 33 to Bitch Creek, and nutrients were listed as the pollutant of concern for the segment from Highway 33 to Bitch Creek.

In 1997, DEQ began collecting BURP data in nonwadeable streams and rivers as part of a field validation study of the Idaho River Index (IRI) developed by researchers at Idaho State University (Royer and Minshall 1996). Beneficial Use Reconnaissance Program protocols for sampling river macroinvertebrates, algae, fish, physicochemical parameters, and habitat are currently proposed for incorporation into DEQ's biologically based approach to assessing the status of beneficial uses (Grafe *et al.* 2002).

Sampling was conducted in the Teton River on three occasions to collect data for the field validation study. Sites at Harrop's Bridge were sampled in 1997 (97-Q002) and 1998 (98-P004), and a site located approximately 2 miles upstream of the confluence of Trail Creek (98-P003) was sampled in 1998. An analysis of the macroinvertebrate data collected at these sites using the procedures described by Royer and Mebane (2000), indicate that the ecological condition of all three sites was good (Table 28). Both sites sampled in 1998 received the maximum IRI score possible of 23, whereas the site sampled in 1997 received a score of 19. Scores between 16 and 23 indicate good ecological condition, scores between 13 and 16 indicate intermediate ecological condition, and scores less than 13 indicate poor ecological condition (Royer and Mebane 2000).

An analysis of periphyton collected at the time the Teton River sites were sampled provides a slightly different interpretation of ecological condition from that provided by the macroinvertebrate data. Periphyton, or algae growing on the surface of rocks, was collected and submitted for analysis by Frank Acker of The Academy of Natural Sciences in Philadelphia.

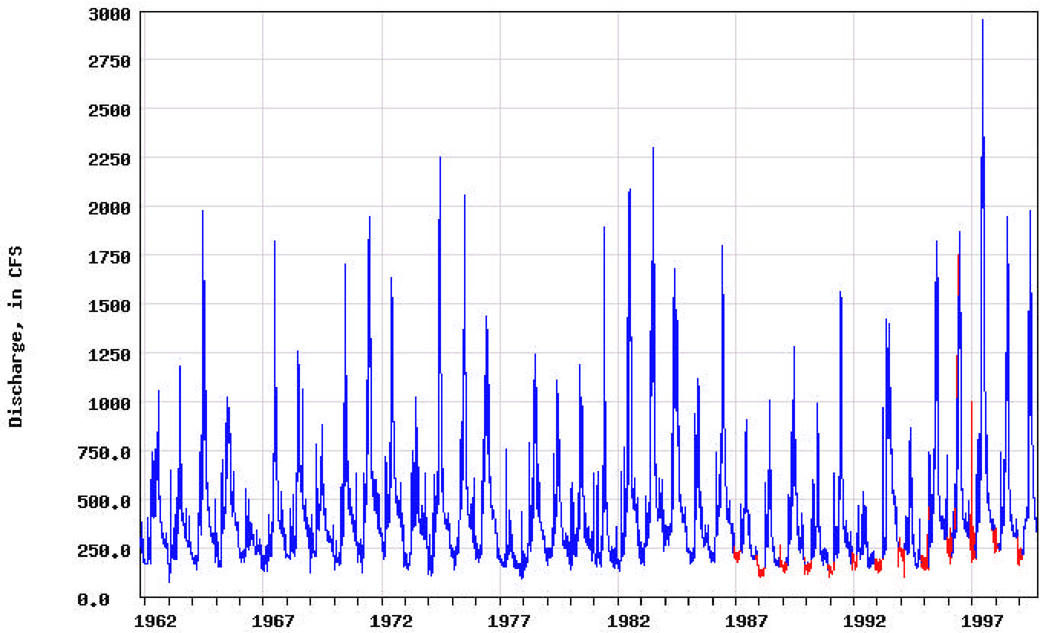

Figure 53. Discharge data recorded from 1961 through 1999 at USGS gage 13052200, *Teton River above South Leigh Creek near Driggs, ID.*
Source: USGS data retrieval site at http://waterdata.usgs.gov/nwis-w/ID

Table 28. Idaho River Index scores for three Teton River sites sampled by DEQ (after Royer and Mebane 2000).

Idaho River Index Parameters and Scores	Sampling Site Harrop’s Bridge (97-Q002)	 Upstream of Trail Creek (98-P003)	 Harrop's Bridge (98-P004)
METRICS			
Number of Taxa	26	68	80
Number of EPT[1] Taxa	13	24	32
Percent Elmidae	3.6	6.9	9.0
Percent Dominant Taxa	32	23	20
Percent Predators	3.3	8.8	4.4
METRIC SCORE			
Number of Taxa	5	5	5
Number of EPT Taxa	3	5	5
Percent Elmidae	5	5	5
Percent Dominant Taxon	5	5	5
Percent Predators	1	3	3
IRI Score	19	23	23
PERCENTAGE OF MAXIMUM POSSIBLE SCORE	83	100	100

[1] Insects of the orders Ephemeroptera, Plecoptera, and Trichoptera

Based on criteria developed for the state of Montana that incorporate factors such as number of diatom valves, diversity of diatom valves, and number of deformed diatom valves, Acker (1999) concluded that the sites indicated full support of aquatic life uses with only minor impairment. His specific comments, based only on visual inspection of slides of diatoms, are as follows:

> At Harrop’s Bridge (97-Q002): Physical disturbance noted by the moderately large populations of *Achnanthes minutissima*. In addition, nutrient enrichment is indicated.
>
> Upstream of Trail Creek (98-P003): A simpler flora than [Salmon River, lower Clayton], indicating this site/river was subjected to more natural or anthropogenic stress. This is probably a smaller river. An abundance of *Navicula* and *Nitzschia* (~ 40% of the cells) may indicate a moderate siltation problem. Minor nutrient enrichment is indicated.
>
> At Harrop’s Bridge (98-P004): Site is subject to more disturbance than [upstream of Trail Creek]. Not as much sedimentation. Plankton diatoms (*F. crotonensis*) indicate stream impoundment. Minor nutrient enrichment evident.

Resource Problems Identified by the USDA and TSCD According to the *Teton Canyon SAWQP Erosion-Sedimentation Evaluation* (Stevenson 1990a) and the *Teton River Basin Study* (USDA 1992), the total sediment yield to the Teton Valley segment of the river at the time of studies was 183,912 tons/year, including 159,677 tons/year from land use and 24,235 tons/year from streambank erosion. Sediment delivery from the Teton Canyon subwatershed, which is located south and west of the Badger Creek subwatershed, was not estimated and is not included in the total yield. This subwatershed contains intermittent and ephemeral streams, but no major tributaries to the Teton River. The sediment yield from approximately upstream of Harrop's Bridge was 110,183 tons/year from land use and 19, 695 tons/year from streambank erosion. Sediment yield downstream of Harrop's Bridge to the confluence included the contribution from the Badger Creek subwatershed, which was 49,494 tons/year for land use and 4,540 tons/year for streambanks. Implementing structural practices was expected to reduce the sediment yield from upstream of Harrop's Bridge by at least 29% and by 30% from downstream of Harrop's Bridge.

The USDA (1992) assumed that each ton of cropland-generated sediment (i.e., sediment from land uses) contained 3 pounds of nitrogen. Based on this assumption, the total amount of nitrogen yield to the Teton Valley segment of the river was 479,031 pounds/year. By reducing sediment yield approximately 30%, nitrogen yield would also be reduced by approximately 30%.

Water Quality Data The water quality data available for the Teton River is discussed in detail in the segment of this assessment entitled, "Nutrient Data."

Fisheries The Teton River fishery appears to be less robust in the Teton Canyon (Bitch Creek to the Teton Dam site) section of the river than the Teton Valley section and the lower section (the section downstream of the Teton Dam site, including the North and South Forks). Preliminary analyses of electrofishing data collected by IDFG in 1999 produced the following results (Schrader 2000b):

1. Of 1,534 trout captured, 657 were captured in the Teton Valley section, 572 were captured in the canyon section, and 305 were captured in the lower section. Trout species included Yellowstone cutthroat trout, wild and hatchery rainbow trout, rainbow trout x cutthroat trout hybrids, and eastern brook trout. Approximately 2 miles of the Teton Valley section were electrofished, 6 miles of the canyon section were electrofished, and 1.25 miles of the lower section were electrofished. The catch per mile was about 328 trout for the Teton Valley section, 95 trout for the canyon section, and 244 trout for the lower section.

2. The total catch rate for trout was highest in the lower section (102 trout/hour), intermediate in the Teton Valley section (82 trout/hour), and lowest in the canyon section (41 trout/hour).

3. Of the 3,016 mountain whitefish and suckers collected, the catch per mile was about 398 in the Teton Valley, 310 in the canyon section, and 286 in the lower section.

4. The total catch rate for mountain whitefish and suckers was highest in the canyon section (134 fish/hour), intermediate in the lower section (119 fish/hour), and lowest in the Teton Valley section (100 trout/hour).

Electrofishing in the canyon section was limited by deep pools and fast-flowing rapids, and most fish were captured near rapids or in pool 24 below Linderman Dam.

Discussion Despite preliminary data indicating that cold water aquatic life beneficial uses of the Teton River upstream of Harrop's Bridge are supported, the process used to interpret these data have not officially been adopted by DEQ. Although specific instances of nuisance aquatic vegetation have not been reported, the measured concentrations of nitrate in the upper Teton River are high relative to other rivers in eastern Idaho. Given the wetland conditions of the upper river (refer to section entitled, "Fate of Residual Nitrogen in the Teton Subbasin") the possible consequences of these concentrations are currently unknown.

Conclusions Conclusions regarding the water quality status of the Teton River are listed below.

1. Development of TMDLs for sediment and nutrients are appropriate.

2. To support beneficial uses, the water quality targets for sediment and nutrients shown in Table 15 should not be exceeded at any location in the Teton Valley segment of the Teton River.

3. All three segments of the Teton Valley portion of the Teton River are listed for habitat alteration. While degraded habitat is evidence of impairment, waterbodies are not considered impaired by pollution that is not a result of the introduction or presence of a pollutant. Since TMDLs are not required for waterbodies impaired by pollution but not a pollutant, the state of Idaho does not develop TMDLs for habitat alteration.

North Fork Teton River

Approximately 16 river miles upstream from the confluence of the Teton River with the Henry's Fork, the Teton River divides into two channels. On USGS topographic maps, the northernmost channel is labeled "Teton River" and the southernmost channel is labeled "South Teton River." But these channels are most commonly known as the North and South Forks of the Teton River.

The forks of the Teton River are located in the Rexburg watershed (Figure 6), which is 48 square miles or 30,598 acres in area. With the exception of small parcels of land managed by BLM, IDFG, or the cities of Rexburg and Sugar City, all land is privately owned. The predominant land uses are agriculture and urban development. The watershed formed on the floodplain of the Teton River and on the floodplain and terraces of the Henry's Fork River. Soils are deep, fine-textured, nearly level, and moderately to very poorly drained.

The channels of the North and South Forks of the Teton River diverge north of the city of Teton (Figure 54). From approximately 1 mile upstream of the forks, the river channel is strictly confined by levees which continue on either side of the North Fork Teton River for approximately 4 miles downstream of the forks. The channel in the area of the levees is also lined with rip rap consisting of boulder-sized material. Much of this material was put into place during channel restoration work conducted by the Army Corps of Engineers at the request of the Soil Conservation Service following collapse of the Teton Dam in 1976 (USACE 1977).

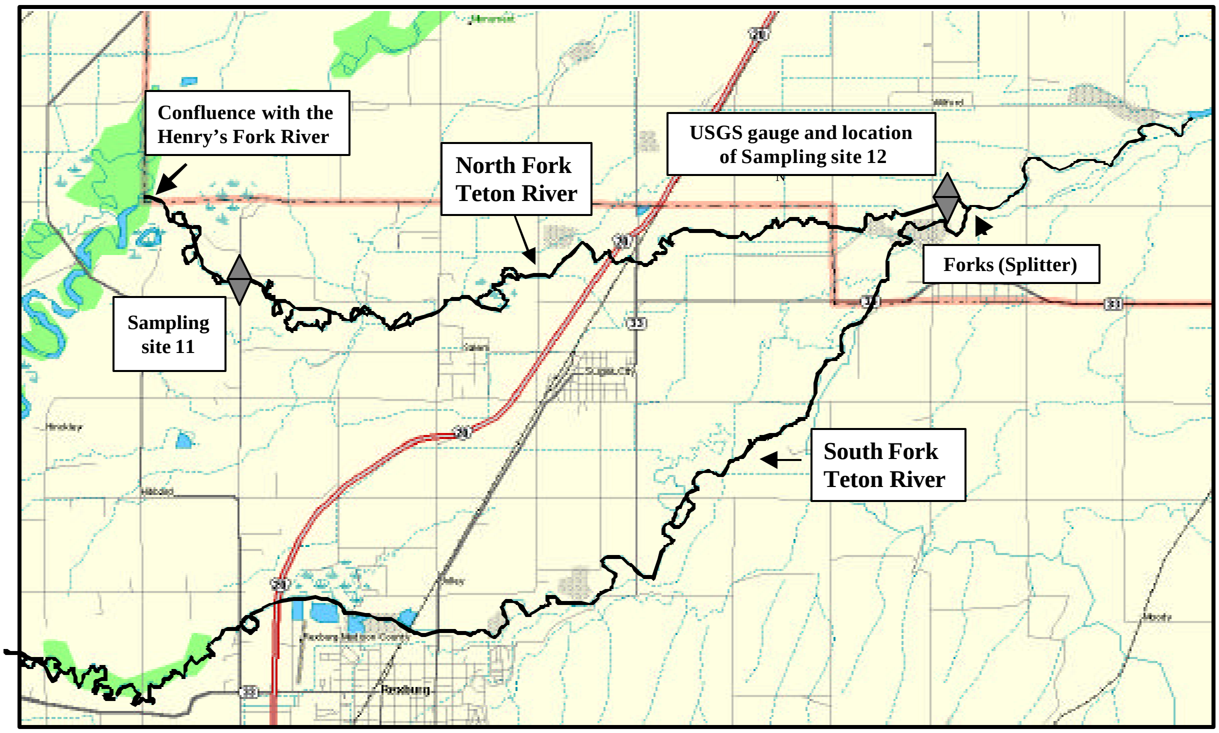

Figure 54. North Fork of the Teton River showing boundaries and locations of sites sampled by DEQ in 2000.

Flooding following collapse of the dam caused extensive structural damage to the North Fork Teton River channel and significantly altered the riparian area by destroying cottonwood and other large deciduous trees. From August to December 1976, water was diverted from the North Fork Teton River to facilitate clean up and to restore its capacity for carrying flood flows (USDA 1982).

Flow Discharge in the North Fork Teton River has been measured discontinuously since 1908 by the USGS at gage 13055198, *North Fork Teton River at Teton, ID.* The gage is located north of the city of Teton and approximately 0.5 miles downstream of the point at which the north and south forks diverge (Figure 55). The range of daily discharge values from 1977 to 1999 was 5 to 2,500 cfs.

Flow from the mainstem Teton River to the north and south forks is controlled by a structure known as the splitter. This concrete structure, located at the point at which the forks diverge, has four regulating gates on the South Fork Teton River and two on the North Fork Teton River. The structure was built shortly after the 1976 Teton Dam flood under the direction of Fremont County with funds from the Federal Emergency Management Act. The splitter replaced a concrete apron on the South Fork Teton River that had holes for steel pins in front of which flashboards were placed to make a removable dam. The water is regulated by the Fremont-Madison Irrigation District to supply water to meet downstream irrigation demands.

During the irrigation season, water in the North Fork Teton River may originate from the Teton River, the Henry's Fork River, or exchange wells. Irrigation return or supplemental flows are supplied from the Henry's Fork River via the Consolidated Farmer's Friend and Salem Union Canals (Figure 56). Water is diverted from the North Fork Teton River to the Pincock-Byington Canal, the Teton Island Feeder, the Salem Union B Stock Canal (formerly the North Salem Agriculture and Milling Canal), the Roxana Canal, the Island Ward Canal, and the Saurey-Somers Canal. Some of the diverted water discharges to the South Fork Teton River or returns via drains to the North Fork Teton River (Bagley 2001 and FMID 1992). The Teton Island Feeder sometimes takes all of the water in the North Fork Teton River, but flow is restored below the diversion by subwater and return flows (Swensen 1998). The distance and time that the channel is dewatered has not been well documented, but in 1979, a 1-mile section was dewatered for two weeks because of irrigation diversions (USDA 1982).

§303(d)-Listed Segment The North Fork Teton River is §303(d)-listed from the forks to the Henry's Fork River. The pollutants of concern are sediment and nutrients.

The beneficial uses of the North Fork Teton River have not been assessed by DEQ using BURP data. Two sites were visited in September 1995 by a BURP sampling crew, but samples were not collected because the channel was not wadeable at either location.

Resource Problems The North Fork Teton River was originally placed on Idaho's §303(d) list because it was listed as an impaired stream segment in *The 1992 Idaho Water Quality Status Report* (DEQ 1992). Irrigated crop production, pastureland treatment, and channelization were identified by DEQ as sources of impairment; siltation/sedimentation and nutrients, including nitrate, were identified as pollutants.

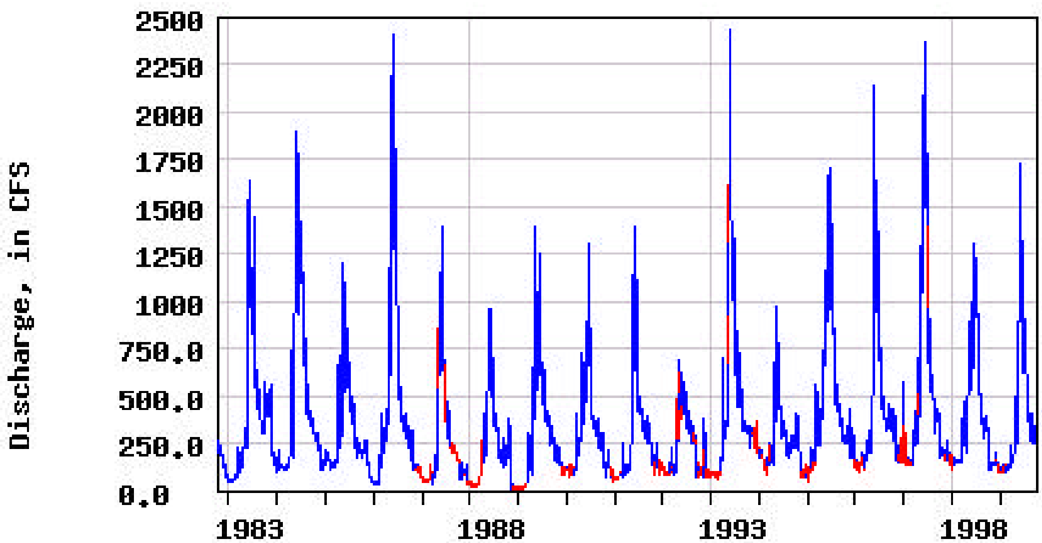

Figure 55. Discharge data recorded or estimated since 1982 at USGS gage 13055198, *North Fork Teton River at Teton, ID.* **Source: USGS data retrieval site at http://waterdata.usgs.gov/nwis-w/ID.**

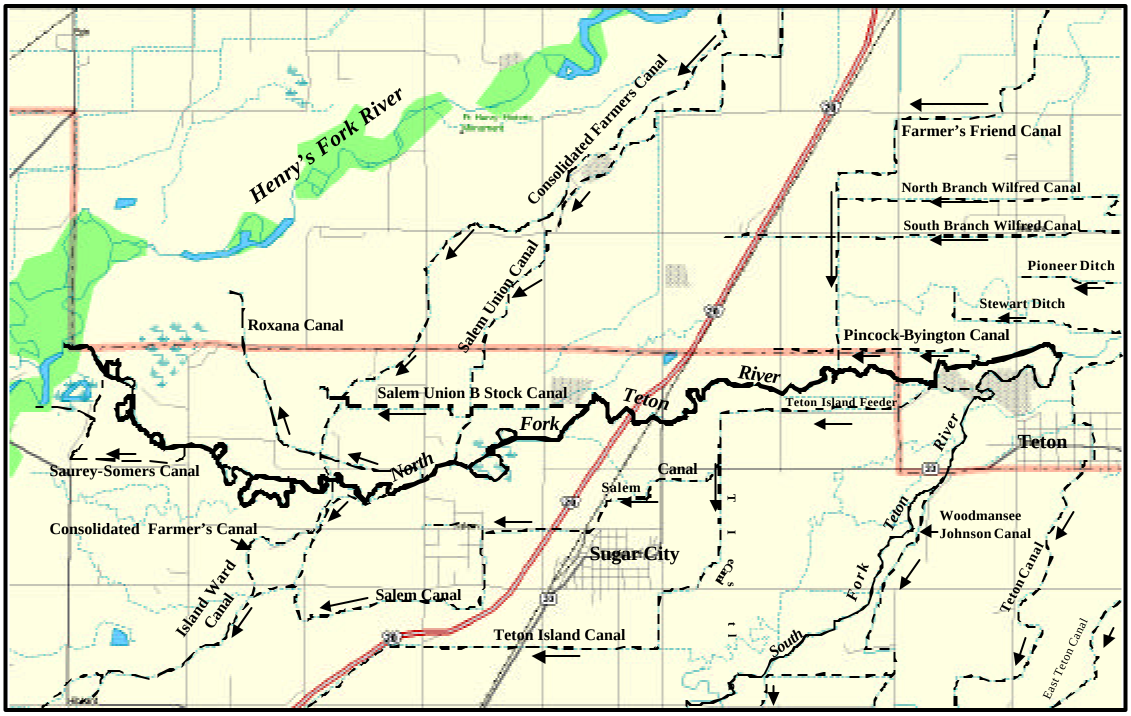

Figure 56. North Fork of the Teton River showing irrigation diversions and irrigation return flows.

Water Quality Data Water quality and benthic macroinvertebrate data were collected by researchers affiliated with Idaho State University at four sites on the North Fork Teton River from December 1976 through July 1980 (USDA 1982) and again at one site in August 1998 (Thomas *et al.* 1999). Limited analyses were performed on a water sample collected in June 1999 (Minshall 2000) and on samples collected by DEQ at two locations on four dates in summer 2000 (Appendix I).

Nitrate concentrations measured in samples of water collected from the North Fork Teton River in 1998, 1999, and 2000 ranged from 0.06 to 0.29 mg/L, remaining below the target of less than 0.3 mg/L. However, all of these samples were collected during the summer months when nitrate concentrations in the Teton Subbasin normally reach their lowest levels. Data collected during all seasons from 1976 to 1980 showed that nitrate concentrations were less than 0.32 mg/L in July and August and more than 0.6 mg/L in late December and January. Although these data were collected more than 20 years ago, recent data collected upstream of the North Fork Teton River at the *Teton River near St. Anthony* gage indicate that these nitrate concentrations are probably representative of current conditions.

Nitrate data collected at two sites on the North Fork Teton River in August 2000 appear to reflect the influence of flow diversions and returns on nitrate concentrations during the irrigation season. Concentrations of nitrate in the North Fork Teton River should approximate the concentrations measured at the *Teton River near St. Anthony* gage. In August 1993, concentrations of $NO_3 + NO_2$ ranged from 0.26 to 0.35 mg/L; in August 1994, the concentration was 0.14 mg/L; and in August 1996, the concentration was 0.41 mg/L. In August 2000, the concentration of nitrate was 0.29 mg/L at the upstream site, but only 0.06 mg/L at the downstream site. The lower concentration at the downstream site indicates that the nitrate concentration was diluted as water was diverted from the North Fork Teton River to canals and replaced by supplemental water and irrigation returns from the Henry's Fork or exchange wells.

The results of water quality sampling conducted by DEQ in 2000 did not indicate high concentrations of suspended sediment in the North Fork Teton River at the locations and times sampled (Appendix I). The maximum concentration of TSS (9.5 mg/L) was far below the designated target of 80 mg/L, and maximum turbidity (7.9 NTU) was far below the criterion specified in Idaho's water quality standards (i.e., not greater than 50 NTU above background). Substrate particle size was measured at four sites on eight occasions from November 1976 to August 1980 (USDA 1982). These data were intended to show changes in particle size distribution following flood restoration work, and therefore provide a good baseline for evaluating the amount of sediment deposited in the North Fork Teton River since that time. Substrate particle size data could not be collected at the sites sampled by DEQ in 2000 because of the depth of water in the channel, so no comparison was made.

Fisheries Despite occasional dry conditions, recent data collected by IDFG show that trout migrate between the Henry's Fork to the canyon area of the Teton River via the North Fork Teton River. Preliminary analysis of 1998-1999 radiotelemetry data indicated that one cutthroat trout and two rainbow trout hybrids migrated from the North Fork Teton River to spawn in the Henry's Fork (Schrader 2000b). None of the 79 radiotagged fish monitored during the study appeared to spawn in the North Fork Teton River. Electrofishing of an approximate 2-mile section of the North Fork Teton River immediately upstream of its confluence with the Henry's Fork produced a catch rate of 149 trout per hour and 141 mountain whitefish and suckers per hour (Schrader 2000b). The catch rate for trout in the North Fork Teton River was higher than in the South Fork Teton River or sections of the Teton River between Bitch Creek and the Teton Dam site.

Discussion The support status of aquatic life beneficial uses in the North Fork Teton River have not been assessed by DEQ because the depth of water in the channel at the time sampling was attempted precluded use of the wadeable stream BURP protocol. Thomas *et al.* (1999) collected macroinvertebrates in 1998 approximately one mile upstream of the confluence of the North Fork Teton River with the Henry's Fork. They assessed the data using the Idaho Medium River Index developed by Royer and Minshall (1996). This Index rates ecological condition on a scale of 0 to 30, with scores less than 19 indicating poor conditions, scores of 19 to 26 indicating medium ecological conditions, and scores of 26 to 30 indicating good ecological conditions. The score for the North Fork Teton River indicated that its condition was at the transition between poor and medium. Fisheries data collected by IDFG indicate that trout and mountain whitefish occur in relatively large numbers in the lower two miles of the North Fork Teton River, and that cutthroat trout and rainbow trout hybrids migrate from the Canyon area of the Teton River through the North Fork Teton River to spawn in the Henry's Fork (Schrader 2000b). Salmonid spawning is a designated beneficial use of the North Fork Teton River, but this use was not observed during the IDFG study.

Analytical values for suspended sediment and turbidity during the summer of 2000 were well below the numeric criteria for these parameters. But it is unlikely that excessive sediment in the water column would occur except during infrequent, high-flow events. Therefore, the most appropriate indicator of sediment impairment is concentrations of substrate surface and subsurface sediment, but water depths precluded measurement of these parameters in 2000. Although substrate sediment has not been quantified, control of streambank erosion to reduce property loss is an ongoing concern for landowners, indicating that large amounts of sediment are delivered to the North Fork Teton River through streambank erosion. High rates of streambank erosion on the North Fork Teton River are caused by at least three factors. First, large sections of streambank are unstable because the large woody vegetation that was removed from the riparian area by the Teton flood and flood restoration work has not regenerated. Second, large fluctuations in flow during spring runoff and the irrigation season contribute to channel downcutting, bank cutting, and bank sloughing. Third, channelization of the Teton River above the forks and channelization of the North Fork Teton River below the forks has increased the velocity of water flowing downstream, causing significant movement of streambanks as the stream attempts to reestablish a natural channel and floodplain. These factors necessitate a whole-stream approach to restoration because efforts to stabilize isolated sections of streambank without addressing all streambanks will perpetuate the erosion problem.

Plans to conduct nutrient sampling and a streambank erosion inventory on the North Fork Teton River are currently being developed by the Madison Soil and Water Conservation District, the Rexburg field office of the NRCS, the Idaho Association of Soil Conservation Districts, and DEQ. Sampling for nutrients will permit a more thorough evaluation of flow diversion and supplementation on nitrogen concentrations, and data collected during the streambank erosion inventory will form the basis for developing a sediment TMDL.

Conclusions Conclusions regarding the water quality status of North Fork Teton River are listed below.

1. TMDLs for sediment and nutrients are appropriate.

2. To support beneficial uses, the water quality targets for sediment and nutrients shown in Table 15 should not be exceeded at any location in the North Fork Teton River.

Teton Creek

Teton Creek from Highway 33 to the Teton River appeared on the 1996 §303(d) list, but was removed from the 1998 list because of BURP collected by DEQ in 1995. The Water Quality Subcommittee of the Henry's Fork Watershed Council objected to this change, citing the inadequacy of data used to delist the segment, and asked that DEQ include a review of water quality data and information for Teton Creek in this assessment.

The Teton Creek subwatershed is one of the largest in the upper Teton Subbasin, encompassing an area of 33,260 acres (Figure 7). The North and South Forks of Teton Creek receive discharge from numerous intermittent and perennial channels originating at elevations of up to 10,000 feet. The forks, which are approximately 4 and 6 miles in length, converge at an elevation of 7,000 feet. From the forks, the mainstem of Teton Creek drops less than 1,000 feet in elevation as it flows 16 miles southwest to its confluence with the Teton River.

The forest boundary and Wyoming-Idaho state line divide the Teton Creek subwatershed from east to west. Approximately 12 miles of Teton Creek are located on the Caribou-Caribou-Targhee National Forest in Wyoming, almost 2 miles are located on private land in Wyoming, and 9 miles are located on private land in Idaho. Approximately three-quarters of the subwatershed, as delineated in the *Teton River Basin Study* (USDA 1992), is managed by the Forest Service, slightly more than 1 square mile is managed by the BLM, and the remainder is privately owned. Forest lands are managed for elk and deer winter range, primitive and semi-primitive backcountry recreation, motorized travel, and developed recreation (i.e., the Grand Targhee Ski and Summer Resort). Private lands are used for rangeland, irrigated cropland, and residential development, particularly near the incorporated city of Driggs and unincorporated community of Alta, Wyoming (USDA 1992 and 1997a).

Several ecological units are represented within the Teton Creek subwatershed on the Caribou-Targhee National Forest, and Teton Creek traverses four of them (Table 29). The steep topography, unstable soils, and wet conditions of higher elevations make the upper portion of the subwatershed a source of relatively high background levels of sediment. At lower elevations, the subwatershed consists of an alluvial floodplain overlain by wind-deposited loess. From the state line to just west of Highway 33, the soils are level to gently sloping and well drained; west of the highway to the Teton River the soils are nearly level and poorly drained.

Flow In the 1870s, explorers of the region surrounding the newly created Yellowstone National Park considered Teton Creek a river and major tributary of what was then known as Pierre's River (Thompson and Thompson 1981). Pierre's River was subsequently renamed the Teton River, the North Fork of Pierre's River was renamed Bitch Creek, and what was then known as the Teton River was renamed Teton Creek. Teton Creek remains a major tributary of the upper Teton River, flowing almost 23 miles from its headwaters near the eastern boundary of the Jedediah Smith Wilderness Area to its confluence with the Teton River southwest of Driggs. Based on early survey maps and remnants of cottonwood riparian forest, it appears that flow in Teton Creek was perennial prior to diversion of water for irrigation.

Like most streams originating on the west flank of the Teton Mountain Range, flow in Teton Creek is shown on USGS 7.5-minute topographic maps as perennial from its headwaters to the eastern edge of the Teton Valley. Approximately 1 mile east of the forest boundary, the channel of Teton Creek becomes braided. The main channel continues to be shown as perennial until it reaches the Grand Teton Canal headworks approximately 0.25 miles east of the Idaho-Wyoming border at Alta, Wyoming. In 1977, the approximate maximum diversion at this structure was 320 cfs. At this point, streamflow in the braided channels of Teton Creek changes from perennial to intermittent. The braided channels converge approximately 4 stream miles east of Highway 33. Perennial flow is restored to the channel immediately east of Highway 33. West of the highway, the channel receives flow from numerous unnamed spring creeks and continues to enlarge in size until it reaches the Teton River immediately upstream of Bates Bridge.

Discharge in Teton Creek and associated canals is measured by Water District 1 at the following locations: above all diversions in Wyoming; in Mill Creek, a tributary of Teton Creek in Wyoming; in North, South, and Waddell Canals in Wyoming; in the Grand Teton Canal in Wyoming; in Teton Creek below Grand Teton Canal in Idaho; in Central Canal at the Idaho-Wyoming state line in Idaho; and in Price-Fairbanks Canal in Idaho. Eighteen-year average discharge data for Teton Creek above all diversions indicate that maximum discharge exceeds 450 cfs throughout June, rapidly declines in July to less than 100 cfs by August 1, then continues to decline to less than 20 cfs by the end of November (Figure 56a).

Below the diversions near the Idaho-Wyoming border, the maximum discharge is less than 350 cfs and drops throughout the irrigation season to less than 5 cfs in September (Figure 56b). There are no long-term discharge records for Teton Creek west of Highway 33. In 2000, the discharge measured by DEQ upstream of the confluence of Teton Creek with the Teton River was 54.6 cfs on July 25 and 39.1 cfs on August 21 (Appendix I).

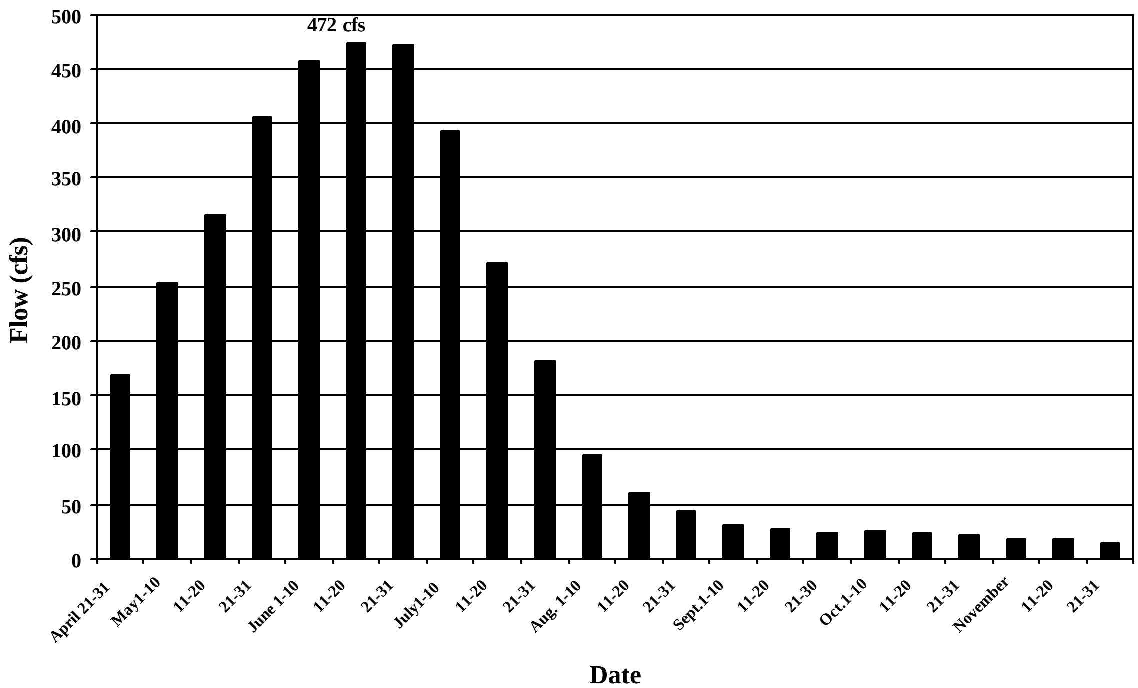

Figure 56a. Eighteen-year average discharge measurements for Teton Creek above all diversions.

A new headgate was installed on Grand Teton Canal 15 years ago (Christensen personal communication). Since then, water has not crossed the state line from Idaho into Wyoming in the original Teton Creek channel during the irrigation season from early May to the beginning of September (Christensen personal communication). Because water is present in the channel between the state line and Highway 33 only during runoff, aquatic life is generally not present in this section of Teton Creek (Christensen personal communication).

According to records maintained by the U.S. Army Corps of Engineers, more than half of the Teton Creek stream channel between the Idaho-Wyoming state line and Highway 33 has been heavily altered by dredging and gravel mining since at least the early 1980s. Some of these stream channel activities either did not require authorization from a regulatory agency or were performed without appropriate authorization. The apparent objectives of the channel alterations were to prevent overbank flooding during runoff, thereby maintaining the value of real estate in the floodplain of Teton Creek (Brochu 2002).

§303(d)-Listed Segment Teton Creek from Highway 33 to the Teton River appeared on the 1996 §303(d) list because of information contained in *The 1992 Idaho Water Quality Status Report* (Table 13) (DEQ 1992). The pollutants considered responsible for impaired water quality were sediment originating from streambank modification and destabilization, and nutrients, including nitrate, originating from pastureland treatment (Appendix F). The segment of Teton Creek shown on the 1996 §303(d) list extends a distance of slightly more than 4 stream miles (Figure 56c).

Based on BURP data collected in 1995, DEQ assessed Teton Creek as supporting its beneficial uses, and removed it from the 1998 §303(d) list. The results of BURP sampling conducted in 1995 indicated that the beneficial use of cold water aquatic life was supported in Teton Creek immediately west of Highway 33 (MBI of 3.61 at site 95-A112) (Figure 56c). Sampling was attempted at two other sites in 1995, but the site downstream of the Idaho-Wyoming state line was dry (95-A095), and the site near the confluence of the creek with Teton River did not contain riffles suitable for sampling (95-B053). Additional BURP sampling in 1997 also indicated that the beneficial use of cold water aquatic life was supported in Teton Creek downstream of the Idaho-Wyoming state line (MBI of 5.87 at site 97-L076). However, discharge records show that the site sampled is typically dry. The stream channel contained water in 1997 because it was a record year for runoff. The discharges measured in Teton Creek peaked in early June at 930 cfs above all diversions and at 848 cfs below Grand Teton Canal. Both of these values are more than twice the eighteen-year average discharges recorded for these locations (Figure 56a). The BURP sampling result obtained in 1997 is therefore not representative of typical conditions, and should not be used to assess beneficial use support.

Table 29. Descriptions of the ecological units traversed by Teton Creek on the Caribou-Targhee National Forest (after Bowerman *et al.* 1999).

Ecological Unit Symbol and Ecological Type Name	Summary Description	Management Considerations and Limitations
1316—ABLA/VAGL, PAMY Koffgo – ABLA/THOC Koffgo – Rock Outcrop Complex, 40 to 70 percent slopes	"....on mountains in the mid portion of the forested zone. ...occurs in glacial troughs, cirques and on the north side of topographically dominant peaks and ridges. Very steep slopes supporting open canopy forests that are frequently dissected by avalanche chutes... [R]ock outcrops and rubble land characterize the landscape. Mixed conifers are represented in the forest canopy. Communities dominated by tall shrubs or subalpine forbs are supported in the avalanche chutes. Mass movements are present in some areas." Average annual precipitation 32 inches; average annual air temperature 35 ^{o}C; elevations from 7,200 to 9,800 feet; geology: mixed.	• Slopes have potential for mass movement • High potential for avalanches • Foot and saddlestock trails, fencing, and use of heavy equipment for woodland harvest severely limited because of slopes
1414—ABLA/VASC, PIAL Winegar – CALE4 Oxyaquic Cryochrepts – Rock Outcrop complex, 4 to 15 percent slopes	"...on cirque floors in the cold, moist portion of the forested zone. ...characterized by rolling slopes that support a mosaic of open canopy forests and riparian communities dominated by subalpine forbs. Scoured rock outcrops and intermittent or perennial streams and ponds are common." Average annual precipitation 45 inches; average annual air temperature 32 ^{o}F; elevations from 9,000 to 9,900 feet; geology: igneous and metamorphic.	• Use of heavy equipment severely limited because soils are too rocky • Fencing and camping severely limited by wetness • Foot and saddlestock trails severely limited because of wetness and because soils erode easily
1999—Valleys, 4 to 25 percent slopes	"...on valleys in the mid portion of the forested zone. ...characterized by stream terraces, ground moraines and mountain footslopes on the floor of glacial troughs. A mosaic of communities dominated by mixed conifers, quaking aspen, mountain shrubs and subalpine or mesic forbs are common. Runout areas for avalanches commonly dissect the unit." Average annual precipitation 28 inches; average annual air temperature 36 ^{o}F; elevations from 6,800 to 8,000 feet; geology: mixed.	• High potential for avalanches; runouts are common • Debris flow or flashflood runout areas are common; high potential for debris flows or flash floods from adjacent south-facing mountain sideslopes during heavy rain events
2609—PIEN Cryaquolls, 2 to 8 percent slopes	"...on cold, moist floodplains in the forested zone. ...characterized by low to high gradient (2 to 8 percent) floodplains in U-shaped mountain valleys. The floodplains vary in width from 40 to 800 feet and streams vary in width from 1 to 15 feet. Microrelief on the floodplain is very broken and irregular. Rosgen stream types A3 and B3 are commonly represented. The streams are perennial or intermittent and seasonal variation in streamflow is dominated by snowmelt runoff. Braided channels and confined meanders are common. Medium to large debris affects up to 30 percent of the active stream channels. Beaver dams are infrequent." Average annual precipitation 25 inches; average annual air temperature 36 ^{o}F; elevations 5,600 to 7,800 feet; geology: alluvium.	• Dynamic riparian systems respond to subtle changes in management or conditions within the ecological unit and on adjacent uplands • Has the potential for frequent flooding of long duration during peak snowmelt period from April through July • Heavy equipment and off-road vehicle use and fencing severely limited by wetness; windthrow hazard severe because of wetness

Resource Problems Identified by the USDA and TSCD The *Teton River Basin Study* (USDA 1992) estimated that the total sediment yield from agricultural lands in the Teton Creek subwatershed was 6,416 tons/year. Of that amount, 68% originated from streambanks and 32% originated from land use. Implementing structural practices, identified as Alternative 2 in the *Teton River Basin Study* (USDA 1992), was expected to reduce total sediment yield to 4,686 tons/year by reducing streambank erosion by 33% and land use erosion by 14%. The majority of agricultural land located in the subwatershed occurs within treatment units 10/11 and 9, with smaller portions in treatment units 12 and 6. Treatment units 10/11 are riparian lands intermixed with upland areas along the Teton River; treatment unit 9 is irrigated cropland with shallow soils. The causes of resource problems identified for treatment units 10/11 were overgrazing in the riparian area; removing stream-side shrubs, trees, and other vegetation; straightening sections of stream channel; improper culvert placement; flooding; stream evolution; reduced sub-water flows; poorly controlled flood irrigation systems; and upland erosion. The causes of resource problems identified for treatment unit 12 were overgrazing of uplands, season of use by livestock, roads, overland runoff/surface and gully erosion, and urbanization/home building (USDA 1992).

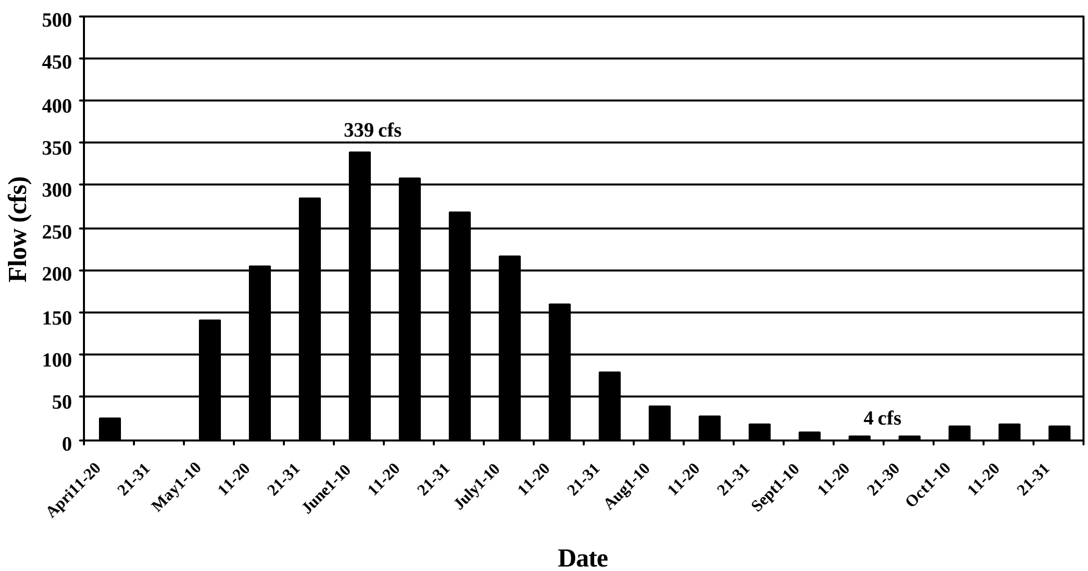

Figure 56b. Eighteen-year average discharge measurements for Teton Creek below diversions near the Idaho-Wyoming border.

The Caribou-Targhee National Forest identified mass wasting as the principal ecological concern affecting riparian quality in the Teton Range (USDA 1997b). In 1985, a mass wasting event occurred on the forest in the Teton Creek subwatershed, sending a large volume of sediment down Teton Creek. This event remains a source of elevated concentrations of sediment in Teton Creek (Christensen personal communication). In 1998, Forest Service biologists conducted a fish survey on Teton Creek and noted that sediment transport was heavy, leaving the water with a green cast. This sediment was apparently glacial in origin.

Water Quality Data Water quality samples were collected by DEQ approximately 1 stream mile above the confluence of Teton Creek with the Teton River on three dates in 2000. Nitrate concentrations were among the highest measured at any location in the subbasin, and increased from 0.92 mg/L on June 26 to 1.64 mg/L on July 25 to 2.13 mg/L on August 21 (Appendix I). These concentrations were higher than the concentrations measured in the Teton River upstream and downstream of the confluence of Teton Creek, indicating that the Teton Creek subwatershed is a source of nitrate. Specific conductance, an indicator of dissolved solids, increased from 180 ìsiemens/cm in June to 260 ìsiemens/cm in July and August, but these results are consistent with other spring-fed streams in Teton Valley.

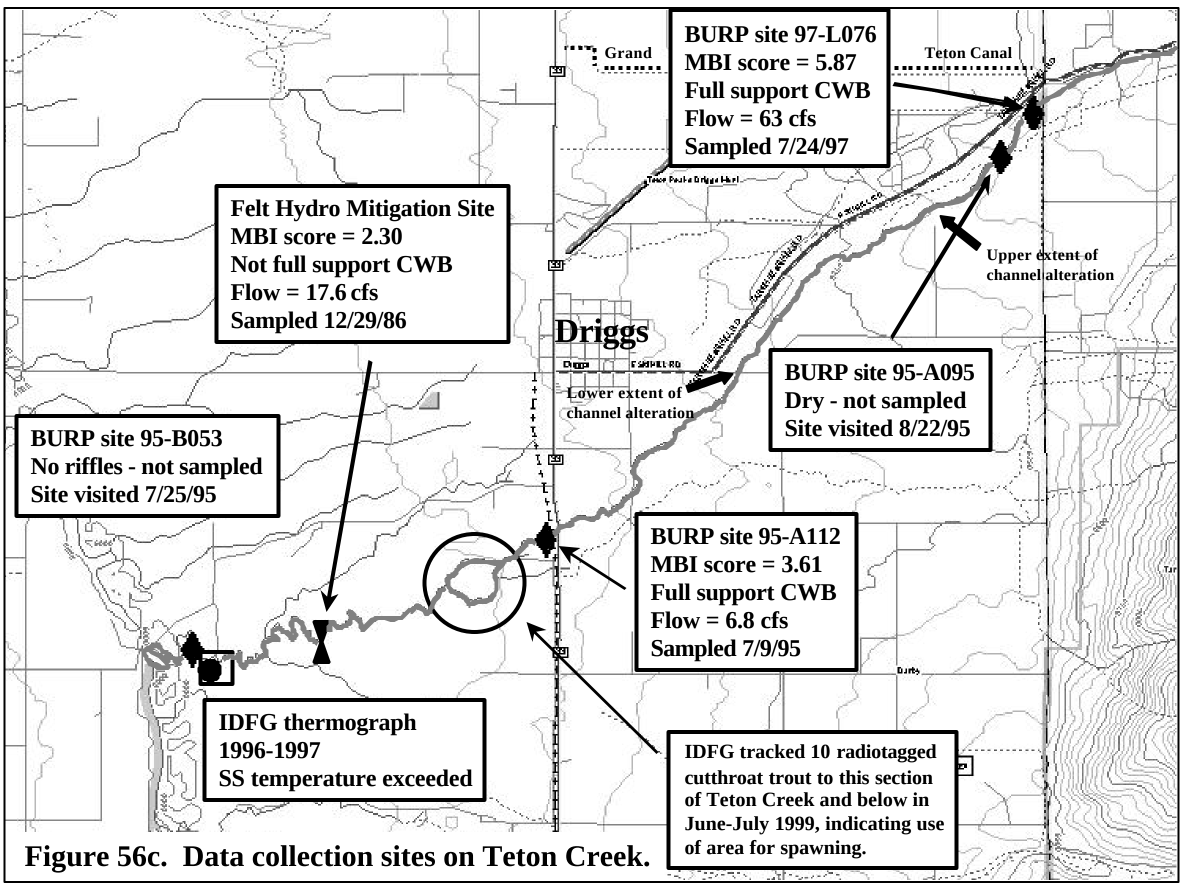

Figure 56c. Data collection sites on Teton Creek.

Neither elevated suspended solids nor increased turbidity was detected at the DEQ sampling location in 2000. The maximum concentration of TSS (3.1 mg/L) was far below the designated target of 80 mg/L, and maximum turbidity (3.1 NTU) was far below the criterion specified in Idaho's water quality standards (i.e., not greater than 50 NTU above background). Turbidity values measured in June 1999 showed a small increase from the state line (3 and 5 NTU) to the site west of the highway near the bicycle path (12 NTU), but again, these values were far below the water quality criterion.

Temperature data were collected by IDFG in 1996 and 1997 at the same location sampled by DEQ in 2000 (i.e. approximately 1 stream mile above the confluence of Teton Creek with the Teton River).

Fisheries Fisheries data for Teton Creek were collected by DEQ in 1996 and 1997, and by the Caribou-Targhee National Forest in 1998. In September 1996, DEQ electrofished a 120-m reach of Teton Creek approximately 150 m below Highway 33. Three year classes of Yellowstone cutthroat trout were collected, including 132 young-of-the-year. In July 1997, a segment of Teton Creek immediately below the Idaho-Wyoming state line was electrofished, but no fish were collected. Three stream reaches were electrofished on the National Forest, but only five cutthroat and rainbow trout were collected, compared to more than 20 brook trout.

Teton Creek below Highway 33 is considered the most important cutthroat trout spawning tributary in the Teton Subbasin (USDA 1992, Schrader 2000a). In 1988, IDFG counted 955 potential spawning sites in 2.8 miles of channel upstream of the confluence with Teton River. In 1998 and 1999, 10 of 79 radiotagged cutthroat trout spawned immediately downstream of Highway 33 (Schrader 2000b).

Felt Hydroelectric Project: Off-site Mitigation on Teton Creek During construction of an access road to the Felt Dam and powerhouse site in 1985, a "substantial amount of material (boulders) was side-cast into the Teton River and Badger Creek" (ERI 1986). The Federal Energy Regulatory Commission (FERC) temporarily halted construction until plans for removing rocks from the streams, stabilizing soils, and replanting slopes could be developed.

The Felt Hydroelectric Project was eventually completed, but not before legal action was taken against Bonneville Pacific Corporation by the EPA, Army Corps of Engineers, and state of Idaho for violations of the CWA at the Felt site and two sites in Twin Falls County (see *United States of America and State of Idaho v. Bonneville Pacific Corporation,* Stipulation and Consent Decree, Civil No. 87 4073). The consent decree stipulated that Bonneville Power Corporation complete all the measures specified in Attachment I, *Mitigation Requirements, Felt Hydroelectric Project, Teton River, Teton County, Idaho.* These measures included upland mitigation for loss of large game habitat, breaking and clearing of rock in Badger Creek to ensure adequate fish access/passage, on-site upland restoration for erosion control, on-site riparian restoration on Badger Creek and the Teton River, and off-site mitigation for approximately 6,500 square feet of aquatic habitat and 6,500 square feet of riparian habitat eliminated from Badger Creek and the Teton River.

The IDFG recommended Teton Creek as the location for off-site mitigation. A remedial study of the site was conducted in 1986 (ERI 1986), streambank stabilization and riparian revegetation were completed in 1987, and monitoring of the treated site and a downstream control site was conducted for five years (ERI 1992). After five years, the percentage of fine sediment in substrate decreased at the treated site but increased at the control site. Vegetation cover at the treatment site increased 10-20% and embeddedness decreased 20-25%.

The results of the Felt Hydroelectric/Teton Creek mitigation project are especially valuable because monitoring was conducted over a five-year period, the treatment site was compared with an untreated control site, and both physical and biological parameters were measured. Data contained in project reports provide a good basis for assessing future water quality implementation projects on Teton Creek.

Discussion Teton Creek consists of two hydrologically distinct segments. The source of water in the upper segment is snowmelt runoff; the source of water in the lower segment is upwelling subsurface water and springs located immediately west of Highway 33. Because of the unique hydrologic characteristics of these two segments, the Henry's Fork Watershed Council Water Quality Subcommittee recommended in 1999 that Teton Creek be separated into two segments for the purpose of assessing beneficial uses (Appendix D). Due to the absence of flow in the segment of Teton Creek from the Idaho-Wyoming state line to Highway 33, this segment cannot support aquatic life. However, historic and ongoing stream channel alteration in this segment has the potential to significantly degrade water quality in the lower segment from Highway 33 to the Teton River. This segment is the most important Yellowstone cutthroat trout spawning tributary in the Teton Subbasin, and must be monitored carefully for changes in water and substrate quality.

SUMMARY OF PAST AND PRESENT POLLUTION CONTROL EFFORTS

Agricultural Water Quality Projects

In the 1980s and early 1990s, the TSCD, Madison Soil and Water Conservation District (MSWCD), and Yellowstone Soil Conservation District made several efforts to procure funding for implementation of water quality projects through the State Agricultural Water Quality Project (SAWQP). At that time, DEQ administered the SAWQP, though projects were approved jointly by DEQ and the Idaho Soil Conservation Commission (SCC). The application process involved the following steps:

1. The district applied for funding to develop a planning project final report.

2. The district developed a planning project final report using technical support of the NRCS and SCC. The planning project final report was a thoroughly detailed study that included descriptions of the topography, climate, land use, soils, wildlife resources, water quality, and the local economy of the project area; descriptions of treatment units and appropriate best management practices; a cost analysis of the project, including comparisons of treatment alternatives; and a plan for implementation.

3. If the planning project final report was approved by DEQ and SCC, the district submitted an application to fund an implementation project.

4. The district developed a plan of operations for the implementation project, which, if approved, became part of the SAWQP grant agreement.

Several projects received funding for planning, but did not receive funding for implementation. The numerous planning documents produced for unfunded projects are valuable references that contain extensive information regarding land use, agricultural practices, characterization of nonpoint-source pollution originating on agricultural lands, and proposals for pollution mitigation. Copies of most of these documents are available only from the conservation districts, NRCS field offices, SCC, or DEQ.

Planning projects for Milk Creek, Canyon Creek, and Teton Canyon were funded in the mid-1980s. In conjunction with the planning projects, DEQ provided technical assistance to the districts by performing water quality monitoring in the project areas. The Milk Creek Water Quality Project (TSCD 1987), West Canyon Creek Planning Project AG-P-13 (MSWCD 1988), and Teton Canyon Water Quality Planning Project (TSCD 1991) all include water quality data that were also published as DEQ water quality status reports (Drewes 1987, 1988, and 1993). The Teton and Madison Conservation Districts proposed an East Canyon Creek Planning Project, but it was not completed because technical assistance from DEQ was not available. The area covered by these projects included the Teton River subwatershed from the mouth of Horseshoe Creek to the mouth of Canyon Creek, and the Canyon Creek, Milk Creek, Packsaddle Creek, Horseshoe Creek, Bitch Creek, and Badger Creek subwatersheds (Ray 1999).

An implementation grant application for the Teton River subwatershed (TSCD 1990) was submitted in draft form in 1990. This subwatershed was identified by the TSCD as its highest priority for implementation, and included the Teton River drainage downstream of the mouth of Horseshoe Creek to the mouth of Canyon Creek, exclusive of the subwatersheds included in the Teton Canyon Water Quality Planning Project (TSCD 1991). An implementation grant was awarded for the portion of the Teton River subwatershed south of the mouth of Badger Creek, and in 1991, the Packsaddle Creek subwatershed was added to the project, described in *Plan of Operations: Teton River Implementation Project*. More than $1.5 million was obligated to this project for a 10-year period extending from April 1991 to April 2001 (Ray 1999).

Because the Teton Canyon Water Quality Planning Project incorporated the Milk Creek and West Canyon Creek project areas, implementation funding for the latter projects was deferred, though it is unclear whether a request for implementation funds for the former project was ever made. DEQ correspondence indicates that the Madison SWCD was advised in 1988 that a request for implementation funding of the Canyon Creek project could be submitted after the Teton Canyon Planning Project was completed. An implementation grant application for North Canyon Creek was submitted by Madison SWCD and TSCD in 1994, but the project did not receive SAWQP funding (Ray 1999).

In 1992, the Teton River Basin Study (USDA 1992) was completed at the request of the Teton SCD by the USDA Soil Conservation Service and Forest Service in cooperation with the IDFG. The study area encompassed the Teton River drainage south of Harrop's Bridge at Highway 33, and, with the exception of the Packsaddle Creek subwatershed, did not coincide with the areas addressed by the Teton Canyon planning project or the Teton River implementation project. The study was completed in anticipation of funding through the Watershed Protection and Flood Prevention Act (Public Law 83-566), administered by the USDA. Before the draft preauthorization report for funding could be completed, SAWQP funding for the Teton River Sub-Watershed Project and another project on Bitch Creek was approved, and implementation of the Teton River Basin Study was deferred because of the limited availability of NRCS staff (Ray 1999).

Application for funding of the Bitch Creek project was submitted jointly by the Teton and Yellowstone Soil Conservation Districts in 1994. This application consisted of a SAWQP implementation grant for the Bitch Creek subwatershed portion of the Teton Canyon Water Quality Planning Project. Grants were awarded to the Yellowstone Soil Conservation District for the north side of the drainage and to the TSCD for the south side of the drainage. The *Plan of Operations: Bitch Creek South Implementation Project* (TSCD 1995) included provisions for a long-term water quality monitoring plan administered by the TSCD.

The Bitch Creek implementation project is unique because it is the only project in eastern Idaho to incorporate long-range monitoring to assess project effectiveness. The objectives of the Bitch Creek monitoring plan (Robinson undated) are to 1) determine the effectiveness of best management practices for reducing sediment and nutrient loading, and improving the status of beneficial uses in Bitch Creek, 2) determine the effect of cropland practices on nutrient concentrations in ground water, and 3) determine the contribution of sediments and nutrients from the Caribou-Targhee National Forest to the total load delivered to Bitch Creek. The project began in 1994 and extends through 2009. Monitoring data collected to date are reported elsewhere in this assessment.

The Teton River Riparian Area Demonstration Project, initiated by the TSCD in 1991, was also intended to include long-term monitoring. The project addressed the effects of livestock grazing on water quality at three locations in the upper Teton River watershed, and was apparently funded with SAWQP and §319 nonpoint-source pollution control monies. DEQ records indicate that best management practices were implemented on the Teton River, but with the exception of initial data gathering on Spring and Warm Creeks in 1991, the monitoring plan was not implemented. The planned monitoring approach was based on an early version of BURP, so water quality parameters were not analyzed.

A major source of funding currently utilized by the Conservation Districts in the Teton Subbasin is the USDA Environmental Quality Incentives Program (EQIP). The Teton, Madison, and Yellowstone districts applied for a $1.85 million multi-year grant in 1998. The program requires a 25% cost share by the landowner, and in the first year of the program, 19 landowners applied for a total of $293,406. The three-district area was awarded only $190,000 in funding; however, which reduced the number of participating landowners to approximately 12 (Ray 1999).

The water quality improvement projects currently being implemented by conservation districts and the NRCS in the Teton Subbasin are summarized in Table 30.

Table 30. Water quality improvement projects currently being implemented in the Teton Subbasin by the Teton Soil Conservation District, Madison Soil and Water Conservation District, and Yellowstone Soil Conservation District.[1]

Project Name	Funding Source and Project Number	Grant Period	Watershed Acres Addressed by Project	Funds Obligated
Teton River Implementation Project	State Agricultural Water Quality Project, AG 32	October 1, 1991 to September 30, 2006	35,320	$1,587,676
Bitch Creek South Implementation Project	State Agricultural Water Quality Project, AG 40	December 20, 1994 to December 20, 2009	53,553	$417,891
USDA Environmental Quality Incentives Program	USDA Natural Resources Conservation Service	1999 to Unknown	Dependent on Funding	$190,000 in 1999
Teton River Riparian Demonstration Project	State Agricultural Water Quality Project and §319, AG-RD-1	April 10, 1991 to April 9, 2001	318	$44,761

[1]Source: Ray 1999.

Future Management Study of the Teton Dam Reservoir Area

More than 20 years after collapse of the Teton Dam, the Fremont-Madison Irrigation District concluded that reconstruction of the dam was economically unfeasible (Swensen 1998). At about the same time, the BOR began evaluating what could or should be done to mitigate the landscape effects caused by the downstream movement of 250,000 acre feet of water and 4,000,000 cubic yards of embankment in a period of only six hours (Randle *et al.* 2000). Consistent with its future management study plan (Randle and Bauman 1997), the BOR has

1. Completed a flood frequency and flow duration analysis for the Teton River basin (England 1998)

2. Documented the geologic, geomorphic and hydraulic conditions of the Teton River upstream of the dam site (Randle *et al.* 2000)

3. Evaluated changes in water temperature in the Teton River from Badger Creek to the dam site using historical data and data collected in 1997 (Bowser 1999)

4. Cooperated with IDFG in a four-year study of the current status of the Teton Canyon fishery (Schrader 2000a).

The findings of the studies referenced above are discussed in several other sections of this report. In general, it should be noted that these studies were conducted to determine the present condition of lands managed by the BOR. Funding has been requested for the 2002 fiscal year to develop a 10-year Resource Management Plan (RMP) for the Teton Canyon. The goals of the RMP are 1) to create a balance of resource development, recreation, and protection of natural and cultural resources for the lands and waters being managed, and 2) to outline for the BOR, the public, and other management agencies the policies and actions that will be implemented (Stout 2000). The RMP will form the basis for future management of the Teton Dam reservoir area by the BOR, which will in turn influence water quality in the Teton River downstream of Badger Creek.

Mahogany Creek Watershed Analysis

The Teton Ranger District of the Caribou-Targhee National Forest completed an analysis of the Mahogany Creek Principal Watershed (022) in 2001. The watershed includes portions of streams within the forest boundary on the east and north slopes of the Big Hole Mountains. The major streams included in the watershed area are Milk, Packsaddle, Horseshoe, Twin, Mahogany, Patterson, Drake, and Murphy Creeks. Historic Forest Service documents and files were reviewed to determine the resources and ecosystem functions of the watershed. Future desired conditions for the watershed will then be developed based on this review, the forest plan, and public preferences. The analysis will be used as an internal planning document, though it will be subject to the National Environmental Policy Act process before any recommendations are implemented (Davy 2000).

Preliminary results of the analysis indicated that several streams were historically inhabited by beaver, and that erosion and stream sedimentation could possibly be reduced by their reintroduction (Mabey 2000). A survey to assess the general condition of Teton River tributaries, and their suitability or need for beaver reintroduction, was conducted by the Forest Service from June 21 through August 21, 2000. Streams surveyed included those in the Mahogany Creek Principal Watershed and several streams that originate in the Teton and Snake River Ranges (e.g., Darby, Badger, Moose and Trail Creeks). The survey received financial support from the Greater Yellowstone Coordinating Committee and Idaho DEQ, and technical support from the Driggs field office of the NRCS and the TSCD (Blandford 2000). The survey was conducted on approximately 80 miles of streams to determine where beavers might improve riparian and hydrologic conditions. According to Blandford (2000), such improvements would be expected to improve fish habitat, increase late-summer streamflows, reduce stream channel erosion and degradation, and increase sediment storage.

Methods used to conduct the survey were described by Blandford (2000). The streams surveyed were broken into half-mile units, and each unit was walked in its entirety when possible or warranted. A Beaver Transplant Compatibility Matrix form consisting of social, biological/ecological, and habitat suitability parameters was completed for each unit. Stream characteristics were evaluated in comparison to the following guidelines specified in the forest plan: bank stability greater than 80 percent, stream temperature less than 16^{o}C, frequency of woody debris greater than 20 pieces/mile, frequency of pools at least one per five to seven channel widths. The percentage of fine sediment by weight in substrate samples taken from areas considered suitable for spawning was determined using the method described by Grost and Hubert (1991). Streams originating in the Teton Range were also observed and sampled for substrate sediment, but complete surveys were not conducted. These streams included Darby, Teton, South Leigh, North Leigh, and Badger Creeks.

The results of the survey indicate that the following streams provide suitable beaver habitat and would benefit from stream modifications made by beaver colonies: North Moody Creek, the South Fork of Packsaddle Creek, the North Fork of Mahogany Creek, Patterson Creek, Little Pine Creek, and Trail Creek. The survey also produced information indicating that grazing, unauthorized all-terrain vehicle (ATV) travel, failure of culverts, and proximity of roads to stream channels have contributed to stream channel instability, erosion, and sedimentation. The following recommendations and findings are excerpted from the report by Blandford (2000), and include specific management actions that should be implemented by the Forest Service:

> **North Moody Creek** was observed to have a film of fine sediment deposited on the margins and out towards the middle of the stream indicative of a higher than normal sediment load. The following parameters were also not meeting expected values: temperatures of 23.5 ^{0}C, four units had banks that were less than 80% stable, pool frequency was also less than expected. North Moody is ecommended for beaver transplants after grazing issues have been resolved.
>
> **Milk Creek** bank stability is rated at 60% with evidence of repeated overgrazing for several years based on the utilization and form of the willows. Under proper management, this could be a future introduction site.
>
> **South Fork of Packsaddle** is a site recommended for re-introduction. In 1988, there was a "successful" effort to eradicate beaver from this drainage. Units 4 and 5 in this drainage are the sites of an inactive but still stable complex of dams. Re-introduction is recommended to ensure the continued stability of this site and allow further expansion of the beaver complex and riparian zone.
>
> The mainstem of **Horseshoe Creek** is suffering from active erosion and bank instability, and the channel has entrenched 2-4 feet. A wide valley bottom and dense willows make this excellent beaver habitat. There is currently one complex of nine dams on the mainstem at the forest boundary that was built this fall. If these dams do not withstand spring runoff reinforcement of dams will need to be considered. There appears to be enough habitat for two more complexes on the mainstem. Spot data indicates that water temperatures may exceed 16 ^{0}C.

A stream capture event was also documented 100 yards upstream of the confluence of the South Fork Teton River and Horseshoe Creek. A culvert has failed and an old road has captured the stream channel. Severe erosion is occurring in about 150 feet of channel due to unauthorized ATV use.

Mahogany Creek is highly unstable in the lower half of Unit 1 due to removal of beaver in an effort to control collection of water at the diversion. Re-colonization of beaver in this area would be beneficial in restoring stream stability. Options need to be evaluated to determine if there are measures that could be taken to meet the needs of the irrigators to divert water and still maintain channel stability. The **North Fork of Mahogany** is a site where introduction is recommended due to entrenchment and potential beaver migration barriers.

Patterson Creek is recommended for introduction in Units 1 and 2. Bank stability in this stream is low at 75-80%. Overgrazing along this stream is evidenced by browsed willows, bank instability, and forb dominated meadows. There are also numerous trail crossings with related instability.

Little Pine Creek has a healthy beaver complex in Unit 1. Unit 2 has an abandoned beaver complex with a headcut that has proceeded upstream 800' and is now 6' deep. For the time being the headcut has been arrested at the site of an old beaver dam. Without beaver activity at this old complex, the headcut will continue to migrate upstream. Unit 2 had a bank stability rating of 75%. A high temperature of 16 ^{0}C was recorded indicating the guidelines are probably exceeded.

Trail Creek has been impacted by road construction including straightening in several areas some of which have caused entrenchment. In addition, culverts draining inside ditches on the pass itself are causing gullies on the fill slopes with the resultant fine materials being deposited into trail creek. There are two known sites where single beaver dams occur. As previously mentioned at least one beaver was trapped this fall. Introduction of beavers is recommended, as there are no beaver complexes present or signs of reproducing family units. Units 4 and 5 are the best sites for introduction.

Mail Cabin Creek has been captured by a road or trail at its confluence with Trail Creek and is contributing sediment. This site needs to be evaluated for repair.

The results of the substrate sediment sampling conducted during the survey confirmed that stream sediment originates on the National Forest in several subwatersheds throughout Teton Valley, and that sediment sources are not confined to privately owned lands. Blandford (2000) considered substrate consisting of more than 25% particles smaller than 4 mm by weight to be "likely above natural levels" and "spawning impaired." Six samples were collected in each of 23 stream segments, and the average equaled or exceeded 25% fine sediment in eleven of the segments, including the following: South Fork Packsaddle Creek (29%), South Fork Horseshoe

Creek (26%), North Twin Creek (31%), North Fork Mahogany Creek (29%), Mahogany Creek above trailhead (29%), Mahogany Creek below trailhead (27%), Trail Creek at Coal Creek (30%), Moose Creek (25%), Teton Creek below campground (25%), North Leigh Creek below trailhead, and Badger Creek.